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California's Ground Water

STATE OF CALIFORNIA
THE RESOURCES AGENCY
SEPTEMBER 1975

save water

DEPARTMENT OF
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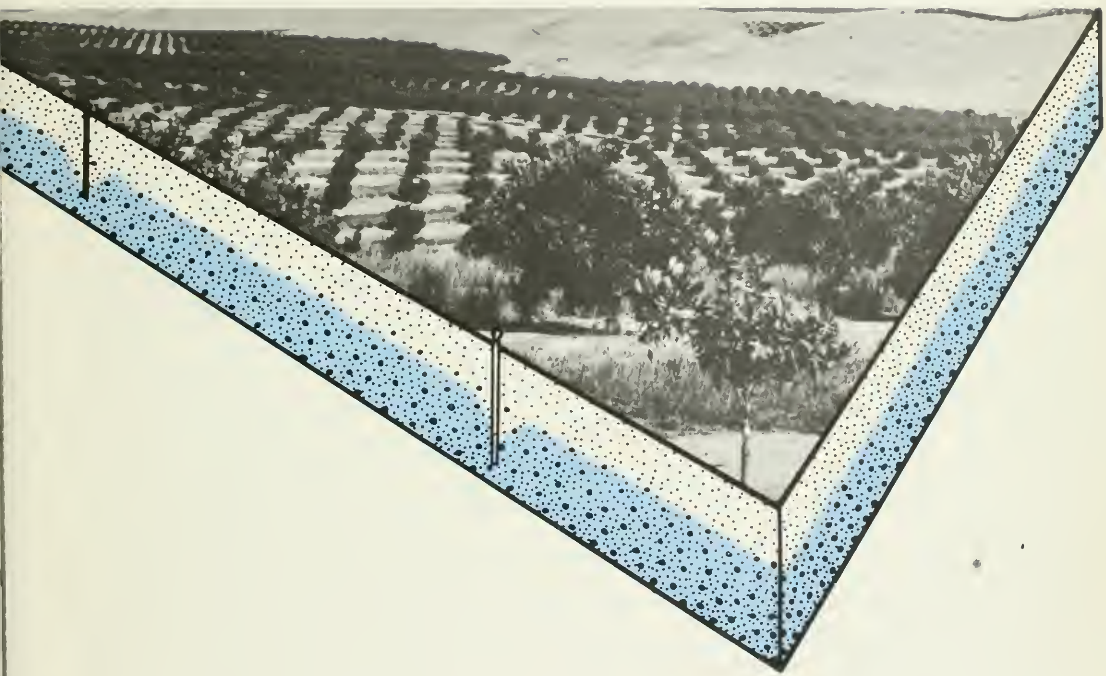
BULLETIN NO. 118



California's Hidden Resource

STATE OF CALIFORNIA
The Resources Agency
Department of Water Resources

BULLETIN No. 118

CALIFORNIA'S GROUND WATER

SEPTEMBER 1975

CLAIRE T. DEDRICK
Secretary for Resources
The Resources Agency

EDMUND G. BROWN JR.
Governor
State of California

RONALD B. ROBIE
Director
Department of Water Resources

FOREWORD

The water in our underground basins and the storage space afforded by those basins comprise one of California's most valuable resources. A significant portion of the total water used each year in California is ground water.

This Bulletin summarizes the known technical information on ground water basins and the extent of their water supplies throughout the State. It also discusses the ways in which ground water basins have been used and misused in the past and suggests better management mechanisms for the future.

By using ground water and surface water supplies together in a planned manner, more complete management of the total water resources is possible. Although both surface and underground water sources are being utilized in many areas of the State today, much of this activity is not providing the maximum benefits that are possible from conjunctive ground and surface water management. Use of storage capacity of ground water basins has a great potential to increase the dependability of presently developed surface water supplies if the two supplies are used conjunctively.

A recent decision of the California Supreme Court has significantly modified legal doctrines relating to ground water. The revised ground water law which resulted will enable more effective use of existing ground water resources.

We must be prepared to use imaginative new approaches to ground water management.

Ronald B. Robie, *Director*
Department of Water Resources
The Resources Agency
State of California

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The Central Valley, California's Largest Ground Water Basin

CHAPTER I. INTRODUCTION, CONCLUSIONS, AND RECOMMENDATIONS

Water has long been a key factor in California's social and economic development. The water has come about equally from ground water (water stored underground in permeable rock or soil formations) and from surface water. Although many reports describing the statewide surface water resource have been published, very few reports have been devoted to a statewide ground water appraisal.

This report provides a summary of the vast amount of information available on individual ground water basins. It also describes past, present, and possible future management of the ground water resource.

Purpose of Report

There is steadily increasing concern for protection of the State's ground water basins and for more effective use of their storage capacity. Legislation has been suggested that would require legal rights to be obtained for use of ground water much like those for the use of surface water. Administrative adjudication, as with surface water, has also been suggested. The recently enacted national "Safe Drinking Water Act" involves regulation of the quality of ground water supplies. There is also widespread interest in the use of underground storage capacity instead of additional large surface reservoirs to regulate the erratic flows of rivers and streams.

The Department of Water Resources and other agencies, particularly the United States Geological Survey, have a wealth of information in reports of studies of individual ground water basins. However, the information has not previously been summarized on a statewide basis for a nontechnical audience.

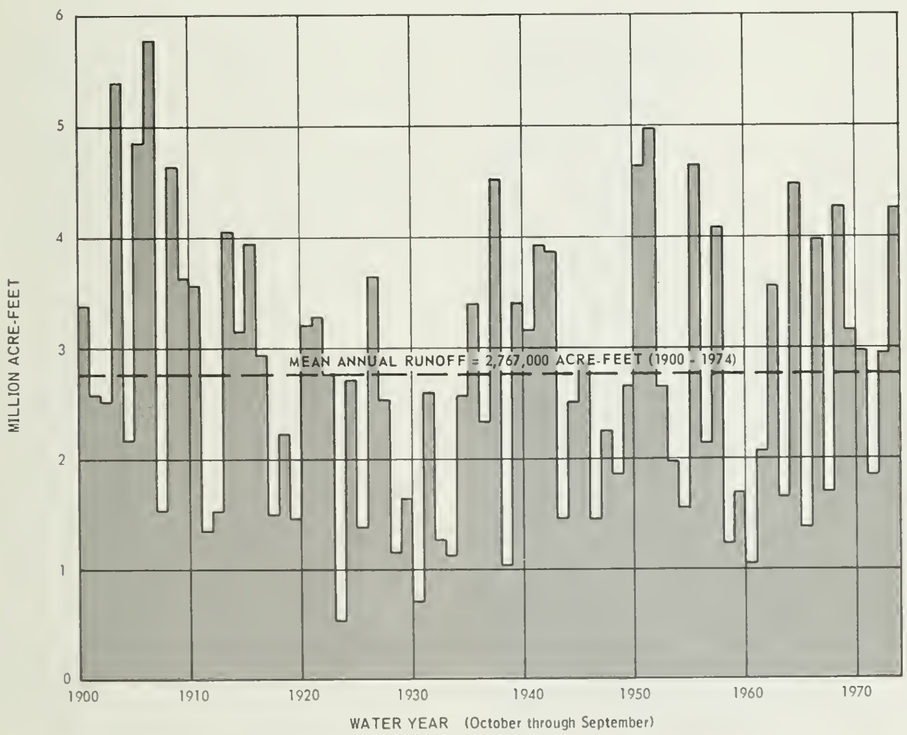


Figure 1. Annual Runoff, American River

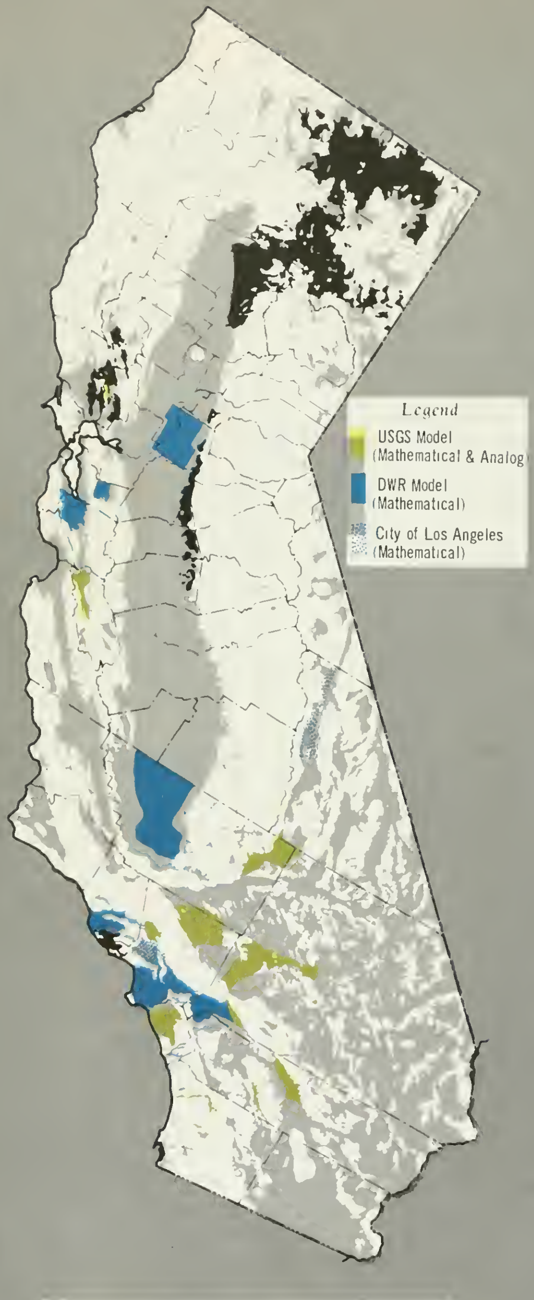


Figure 3. Ground Water Mathematical Models

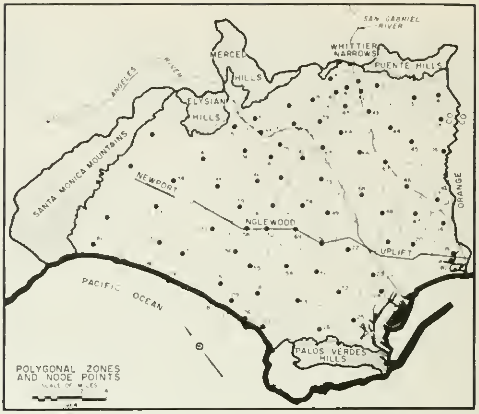


Figure 2. Mathematical Model Nodal Diagram, Los Angeles Area

This report will help those who must make decisions affecting the protection, additional use, and management of the State's ground water resources.

Mathematical models of the hydrology and quality of water in the ground water basins have been developed during the past 20 years, in parallel with the availability of large capacity electronic computers. These models make it possible (1) to understand the relationships among recharge, storage, extraction, and water quality in ground water basins, and (2) to evaluate quantitatively the physical and economic effects of alternative management measures.

Scope of Report

Conclusions and recommendations are presented in this chapter. Chapter II describes the resource. Chapter III contains tabular summaries of information for 248 of the more important ground water basins, along with maps showing their locations. It provides references to 194 of the Department of Water Resources' reports on these basins and to 185 reports of other agencies. Chapter IV discusses ground water basin protection and utilization, and Chapter V describes opportunities for basin management and desirable future studies.

A new California ground water basin map has been prepared and is available separately. It is at a scale of 1:750,000 and is printed on two sheets. The important water-bearing formations are shown, and the ground water basin boundaries are taken from an excellent base geologic map of the State provided by the California Division of Mines and Geology.[1]

[1] "State of California Preliminary Fault and Geologic Map Scale 1:750,000". Preliminary Report No. 13. 1973. California Division of Mines and Geology.

Conclusions

1. About 40 percent of California is underlain by ground water basins. The total storage capacity of all basins is some 1.3 billion acre-feet. The usable storage capacity, excluding that of a large number of the smaller basins where it has not been determined, is 143 million acre-feet.

2. About 40 percent (15 million acre-feet per year) of California's applied water need is obtained from ground water basins. Annual ground water pumping exceeds recharge in some basins and results in an overdraft of 2.2 million acre-feet per year.

3. All ground water contains some dissolved salts. In some parts of California, the quality of the ground water is naturally poor or has been impaired by excessive salts and other solubles, including organic materials and gases. For the most part, however, water quality in the State's ground water basins is suitable for all beneficial uses.

4. Large capacity, high-speed electronic computers capable of solving many equations simultaneously, have made practical the use of mathematical models of the hydrology of ground water basins. This has enabled the Department of Water Resources, in cooperation with local and other agencies, to evaluate the physical and economic consequences of various proposed management plans for a number of important ground water basins.

5. Water could be pumped from some basins without replenishment to support certain industries with an economic life short enough to be supplied by the available water supplies. One such industry is the production of thermal electric power involving the use of brackish ground water for cooling.

6. A recent California Supreme Court decision in *City of Los Angeles* v. *City of San Fernando* will facilitate operation of the ground water basins in conjunction with surface water supplies. In that case the Court held that an agency importing water into a basin has a right to recapture the imported water that percolates into the ground water and can prevent such water from being taken by overlying landowners or appropriators. The Court also held that water rights held by public agencies and public utilities cannot be lost through prescription.

7. California water agencies are completing an era of extensive development of the State's surface water facilities. This presents an opportunity to equally develop ground water resources and assign them an equivalent role in the State's water management plans.

8. Water from California's ground water basins has been the most important single resource contributing to the present development of the State's economy, because water was readily available with low incremental development costs.

9. Use of storage capacity of ground water basins offers the largest potential benefit from the management of the State's resources.

10. Some basins with large supplies of inexpensive surface water require well fields to prevent drainage problems due to rising ground water levels; operating procedures must be developed for such basins to enable the most effective combined use of surface and ground water supplies.

11. The Sacramento Basin Hydrologic Study Area contains 24 significant ground water basins with a total area of 6,400 square miles. The area of one basin alone, Sacramento Valley, is 5,000 square miles; its usable storage capacity is 22 million acre-feet of good-quality water. The basins offer significant potential for management of ground and surface water supplies to help meet statewide water needs.

12. The San Joaquin Basin Hydrologic Study Area contains nine ground water basins, one of which—the San Joaquin Valley—is the largest basin in California. The San Joaquin Valley covers 13,500 square miles, and its ground water basin contains more than 80 million acre-feet of usable storage capacity. In some parts of the basin, annual ground water withdrawal exceeds recharge and the net overdraft is 1.5 million acre-feet. However, water levels in other parts of the basin are rising rapidly as imported surface water replaces ground water as a source of supply. Large areas in the northeast part of the Valley contain well-regulated surface supplies and offer good potential for conjunctive operation of surface and ground water supplies.

13. The South Coastal Hydrologic Study Area contains the most extensively developed and most studied ground water basins in the State. Usable storage capacity of 29 of the 42 basins has been estimated at 10.4 million acre-feet. A part of this storage capacity is being used to store imported surface water, and there is further opportunity for such storage.

14. The Colorado Desert Hydrologic Study Area contains 46 ground water basins. A few, in particular Coachella Valley, are highly developed; most, however, remain unused and several contain brackish water. Most of these basins, and nearby basins in the adjacent South Lahontan Hydrologic Study Area, receive very little annual natural recharge in comparison to existing uses. The Owens Valley ground water basin is one notable exception.

15. a) The California State Water Project facilities should be used for conjunctive operation with ground water basins in Southern California and the San Joaquin Valley at the earliest possible opportunity. Capacity in project aqueducts not required during years of adequate water supply would be used.

b) The operation should be designed for minimum physical, institutional, and economic impact on the ground water basins and their present users.

c) Advance analyses of hydrologic and economic effects of proposed operations can be made for basins for which mathematical models are available.

d) The basins should be those with some storage capacity so that filling the basins will benefit overlying ground water users by decreasing pumping lifts and energy requirements. The alternative would be to use water from a basin during a dry period and then refill it.

Recommendations

1. Reconnaissance level studies of large ground water basins in the Central Valley should be undertaken to examine possible benefits, costs, and problems that could result from use of storage capacity in conjunction with surface supplies to meet statewide water requirements during periods of severe drought.

2. Since there are many opportunities in the State for more comprehensive conjunctive use programs for surface and ground water, federal, state, and local agencies which transport, sell, or distribute surface water supplies should examine their service areas and take meaningful steps to develop programs to use surface and ground water supplies conjunctively.

Glossary

Alluvium—a geologic term describing beds of sand, gravel, silt, and clay deposited by flowing water.

Alluvium (younger)—sand, gravel, silt, and clay deposits of recent geologic age.

Alluvium (older)—sand, gravel, silt, and clay deposits with an age range of 100's of thousands to more than 1 million years.

Aquifer—a geologic formation that stores, transmits, and yields significant quantities of water to wells and springs.

Artesian Well—a well tapping a confined or artesian aquifer in which the static water level stands above the top of the aquifer.

Conjunctive operation—a term used to describe operation of a ground water basin in coordination with a surface water reservoir system. The purpose is to artificially recharge the basin during years of above-average precipitation so that the water can be withdrawn during years of below-average precipitation, when surface supplies are below normal. Conjunctive operation will provide more water at a lower cost than would otherwise be possible.

Consumptive use—the water that evaporates during its use for urban or agricultural purposes.

Dry period—an historic period of years when water supply is much below normal. An example was 1929–34 when the water in Northern California streams averaged only about 38 percent of normal. It has been used as the reference drought situation in much water resource planning. Its statistical period of recurrence is under study.

Economic life—the period needed to repay the investment of money in a facility. Frequently 50 years for water supply projects

Electrical conductivity (EC)—the measure of the ability of water to conduct an electrical current, the magnitude of which depends on the concentration of minerals in the water. Related to total dissolved solids.

Fault—a fracture in the earth's crust, with displacement of one side of the fracture with respect to the other. Frequently acts as a barrier to movement of ground water.

Formation—a geologic term that designates a specific group of underground beds or strata which have been deposited in sequence one above the other and during the same period of geologic time.

Hydraulic gradient—slope of the water table.

Hydrology—the origin, distribution, and circulation of water of the earth—precipitation, streamflow, infiltration, ground water storage, and evaporation.

Hydrology, ground water—the branch of hydrology that deals with ground water—occurrence, movement, replenishment, and depletion.

Injection well—well used for introducing water into an aquifer. Technique used to stop sea water intrusion, replenish an aquifer, or dispose of cooling water.

Lava tube—an underground opening formed during volcanic eruptions.

Locally—a term used to describe a small area within a basin, usually less than one square mile.

Marine sediments—sediments originally laid down in an ancient salt-water body and now above sea level.

Mining—pumping from ground water bodies greatly in excess of replenishment.

Overdraft—the temporary condition of a ground water basin where the amount of water withdrawn by pumping exceeds the amount of water replenishing the basin over a period of time.

Percolation—the flow or trickling of water through the soil or alluvium to the ground water table.

Permeability—the capability of soil or other geologic formation to transmit water.

Porosity—voids or open spaces in alluvium and rocks that can be filled with water.

Potentiometric surface—the surface to which the water in a confined aquifer will rise in tightly cased wells.

Pumping lift—the distance water must be lifted in a well from the well pumping level to ground surface.

Recharge—flow to ground water storage from precipitation, infiltration from streams, and other sources of water.

Safe yield—the maximum quantity of water that can be continuously withdrawn from a ground water basin without adverse effect.

Saline—consisting of or containing salts, the most common of which are potassium, sodium, or magnesium in combination with chloride, nitrate, or carbonate.

Surface supply—water in reservoirs, lakes, or streams; expressed either in terms of rate of flow (cubic feet per second) or volume (acre-feet).

Total dissolved solids (TDS)—the quantity of minerals (salts) in solution in water, usually expressed in milligrams per liter or parts per million.

Transmissivity—rate of flow of water through an aquifer

Tree mold—vertical tube formed by lava solidifying around a tree which decays with time, leaving a hollow hole in the shape of the tree.

Usable storage capacity—the quantity of ground water of acceptable quality that can be economically withdrawn from storage.

Volcanics—material of volcanic origin, such as ash, cinder, lava, or basalt.

Water table—the surface where ground water is encountered in a well in an unconfined aquifer.

Figure 4. Ground Water Basins

CHAPTER II. THE RESOURCE

About 40 percent of the area of California is underlain by ground water basins. The total storage capacity of the basins has been estimated to be about 1.3 billion acre-feet of water. Many of the basins are full of water or nearly so. A conservative estimate of the usable portion of the storage capacity is 143 million acre-feet, more than three times the total surface reservoir storage capacity in the State. These ground water basins presently provide about 40 percent (15 million acre-feet per year) of the applied water needs of the State. However, the annual withdrawal exceeds recharge by about 2.2 million acre-feet. This is the present measure of annual overdraft of the basins.

Origin of Ground Water

Many ground water basins in California are nearly full and always have been. Until a basin is used by man, the amount of water that enters through any recharge area of the basin is equalled by the quantity of water discharged in some manner from the basin.

Since most of California's ground water basins are in relatively arid valleys and most of the precipitation occurs at the higher elevations in the mountains, natural recharge of the ground water basins occurs mainly by percolation from the streams flowing across the valleys. In many basins, this recharge tends to occur in the area where the streams leave the mountains, since this is where the coarser sedimentary material was deposited. The amount of recharge has been increased in many areas by construction of shallow basins to broaden the area of permeable material covered by the water.

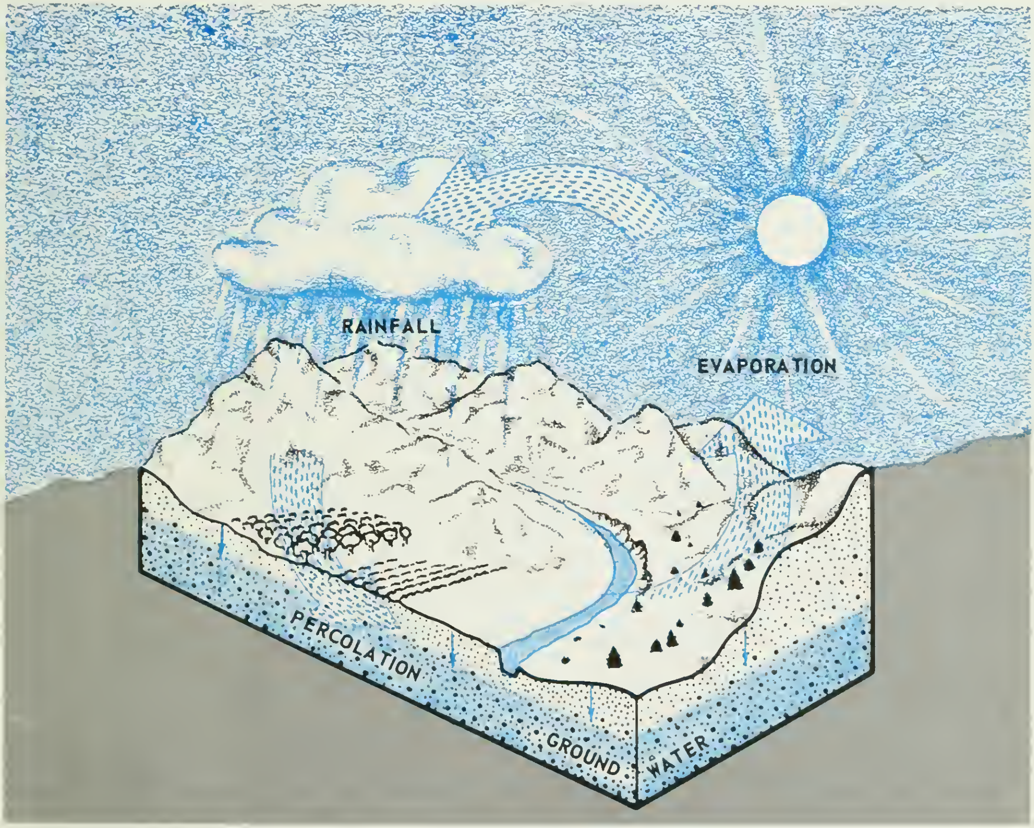


Figure 5. The Hydrologic Cycle

Precipitation falling on the valley floors in most parts of the southern half of the State remains within the depth of soil penetrated by the roots of native plants and is withdrawn and consumed by the plants. Only in years with periods of exceptionally heavy precipitation is there enough moisture in the soil for penetration below the root zone and on into the ground water basin. In the northern part of the State, some percolation from direct precipitation on the valleys usually occurs annually.

When water is used to irrigate crops or for landscaping in urban areas, the amount applied is usually several times as much as natural rainfall. Although the plants grown consume much more water than native vegetation, part of the water usually penetrates below the root zone and on into the ground water basin. During years of above normal precipitation, water in excess of crop requirements is applied in some areas specifically for recharge of underlying ground water basins. Reservoirs have been built in a number of areas of the State to regulate streamflow to increase ground water basin recharge.

Water is imported from great distances to some areas for recharge of ground water basins. The Los Angeles Department of Water and Power has stored large quantities of water from the Owens River underground in the San Fernando Valley. Santa Clara Valley Water District is recharging the Santa Clara Valley ground water basin with water from the South Bay Aqueduct of the California State Water Project. Member agencies of The Metropolitan Water District of Southern California have used large quantities of Colorado River water in their service areas for ground water recharge.

Bulletin No. 160-74, "The California Water Plan—Outlook in 1974", indicated that (1) the ground water basins presently supply about 5.2 million acre-feet annually from natural or deliberate recharge of the basins, and (2) about 7.6 million acre-feet of water that enters the basins due to percolation from canals and distribution systems and excess surface applications. These two sources, plus about 2.2 million acre-feet of average annual overdraft of ground water basins, total 15 million acre-feet per year, or about 40 percent of the total applied water use of California in 1972.

Recharge Basins

Figure 6. Major Aqueducts

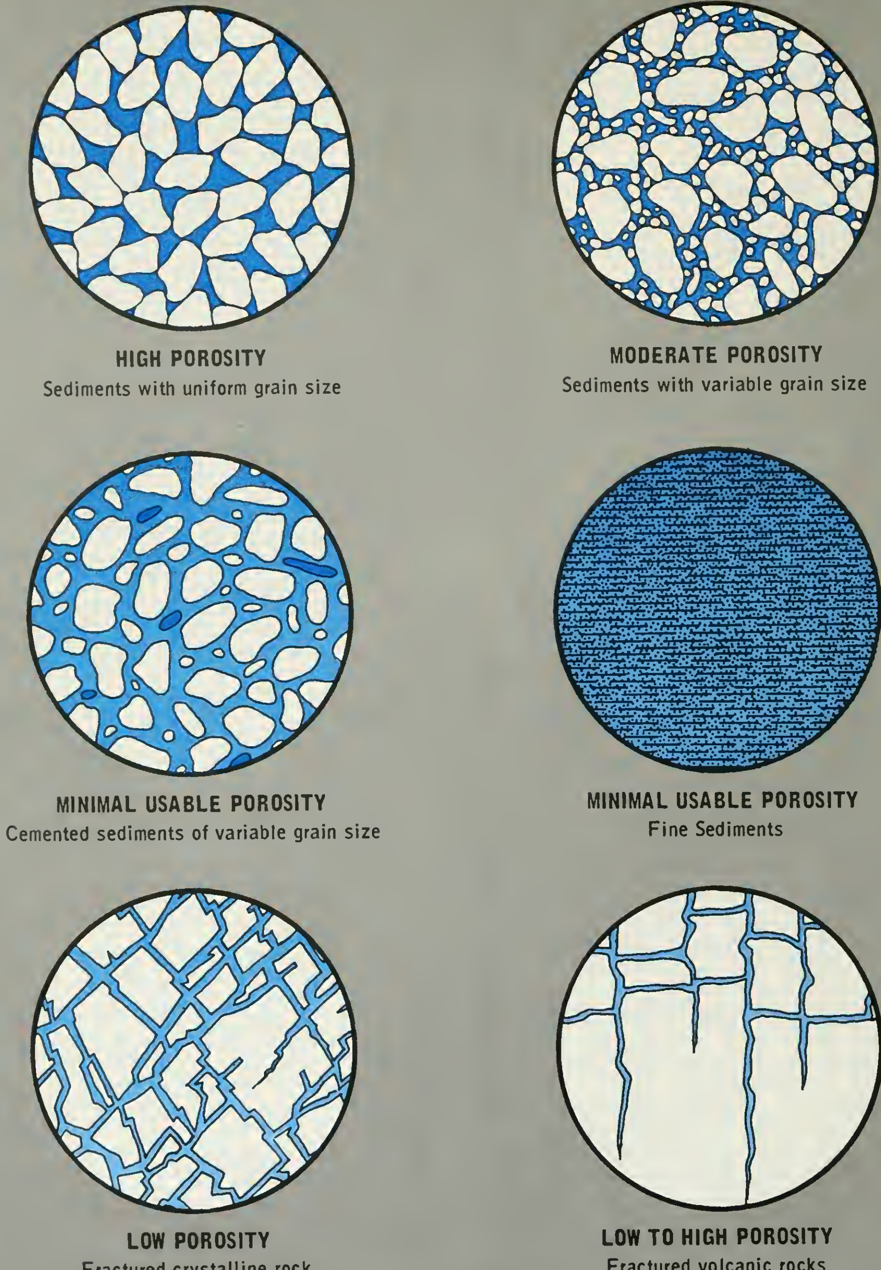
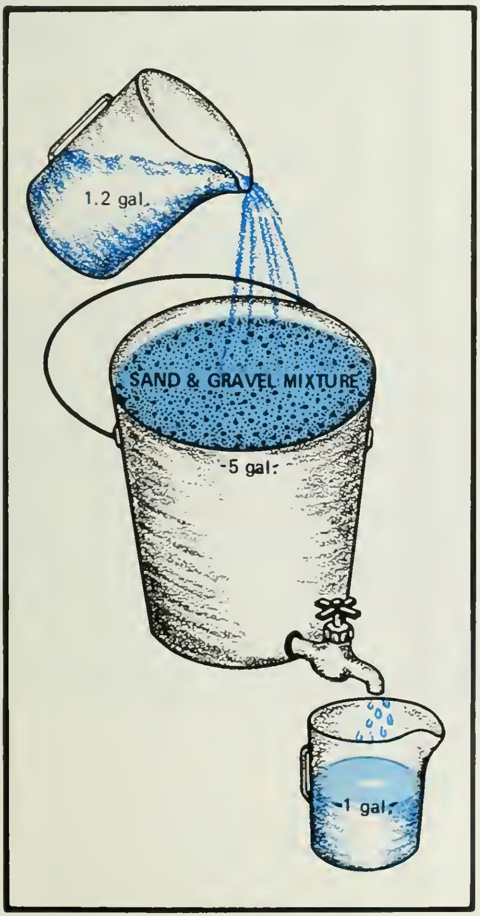


Figure 7. Ground Water in Sediments and Rocks

Younger Alluvium



About 1.5 million acre-feet of the annual overdraft occurs in the San Joaquin Valley. This is 0.5 million acre-feet less than the annual overdraft in the Valley in 1967 as reported in Bulletin No. 160-70, "Water for California, The California Water Plan, Outlook in 1970". Water imported by the Central Valley Project to the San Luis Unit and to the Arvin-Edison area of the Friant Division and to the service area of the California State Water Project caused the decrease in overdraft.

Nature and Occurrence of Ground Water

Most of California's ground water occurs in alluvial material deposited by the existing streams. These alluvial materials, defined as younger alluvium for this report, constitute the alluvial fill in more than 250 valley areas of California. The water in this alluvial material is usually contained in deposits of sand and gravel. These deposits can be compared to a bucket filled with sand, gravel, or a mixture of the two, with water added until the material in the bucket is saturated. The water occupies the very small spaces between the particles. If a drain is opened in the bottom of the bucket, the amount of water flowing out will range from 10 to 25 percent of the volume of the bucket.

Yields will be smaller if the bucket contains fine sand and silt, and larger if most of the material is gravel or medium to coarse sand. Not all of the water will drain from the bucket because some remains on the surface of the particles and in the smallest spaces.

Older Alluvium

Clay and fine silt layers are usually intermingled with the sand and gravel and also are saturated with water but the spaces between the grains are so small that these layers form effective barriers to movement of water. There is a common misconception that ground water occurs in open pools or underground rivers. In fact, if there were such a pool or river in California, it would be filled with sand and gravel in addition to water.

Adjacent to and underlying the younger alluvial materials are extensive areas of older alluvium ranging in age from hundreds of thousands to more than one million years. For the most part these formations are less permeable than the younger alluvium, but some of them yield large quantities of water. They also provide significant recharge areas where they occur in areas of heavy rainfall, or where crossed by streams.

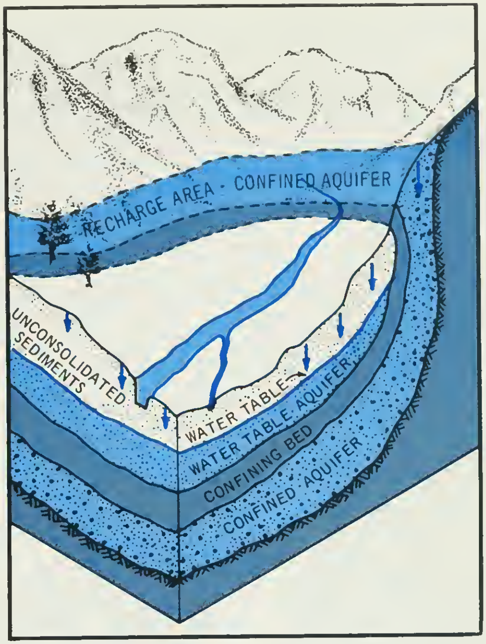


Figure 8. Ground Water in Unconsolidated Sediments

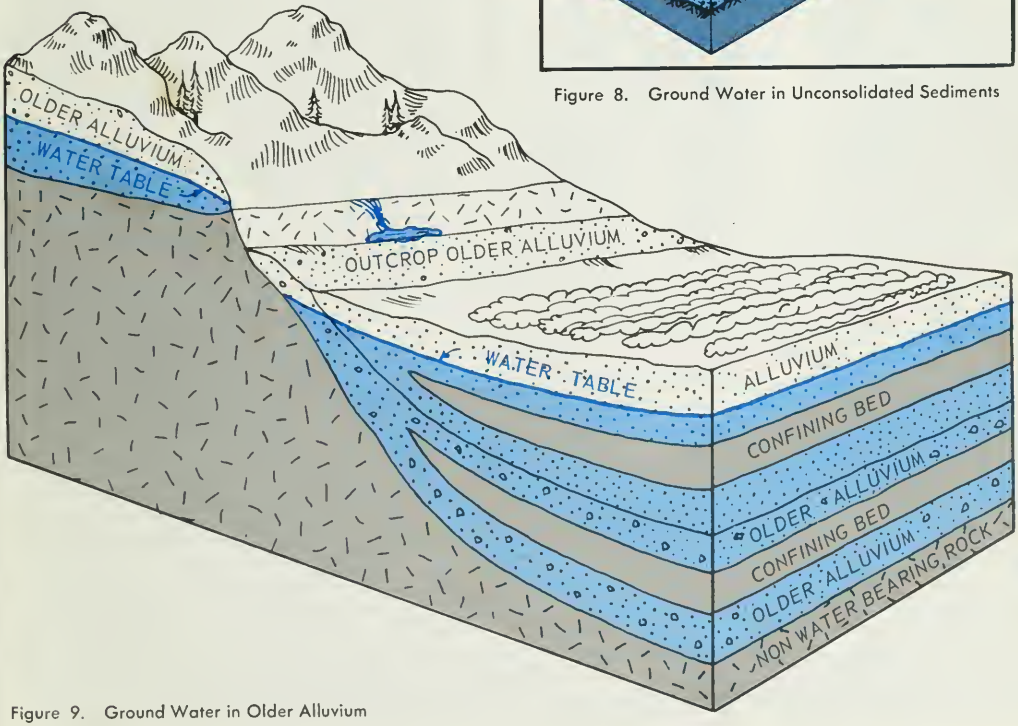


Figure 9. Ground Water in Older Alluvium

Water-bearing Volcanics, Burney Falls

In the northeast corner of the State, northeast of San Francisco Bay, and along the east side of the Central Valley there are extensive areas of volcanics made up of a wide variety of volcanic materials, much of it permeable and able to store ground water and transmit it to wells. Volcanics also occur in the northern portion of Owens Valley, in the desert areas and along coastal Ventura and Los Angeles Counties; however, their potential for ground water development is not clearly defined.

In a few areas in the higher mountains, glacial moraines are sufficiently permeable to provide usable supplies of ground water. In a few coastal areas, thin marine terraces provide usable supplies of ground water.

Limestone in California is insignificant as a water-bearing formation. However, limestone is an important water-bearing formation in some parts of the United States. The State also lacks extensive sedimentary rock formations such as those underlying many thousands of square miles in the area between the Rocky Mountains and the Mississippi River and yielding large quantities of ground water.

In much of the upland areas of the State, fractures and other spaces in harder rock formations yield small quantities of water sufficient for a domestic supply for an individual home or for stock water. Where the harder rock formations are deeply weathered, as in San Diego County, these weathered areas commonly referred to as "residuum", frequently provide usable supplies of ground water for domestic use. Availability of water in such formations can vary widely between areas, even if only a few feet apart. Presence of springs or seeps indicates good locations for wells. Advice of a geologist can greatly decrease the probability of drilling a dry hole in search of water in these rock formations.

Some of the deeper lying sediments in California's ground water basins, especially in the Central Valley, were deposited in sea water. These marine sediments often contain salt water, in some areas 1,000 feet or more below the surface. In other areas, however, such as the Sacramento-San Joaquin Delta, the salt water is as little as 100 feet below the surface. Where these marine sediments have been lifted by geologic forces and the salt water has been flushed out by percolating fresh water, the sediments have become fresh water aquifers supplying local water needs in such areas as coastal Sonoma and Santa Cruz Counties.

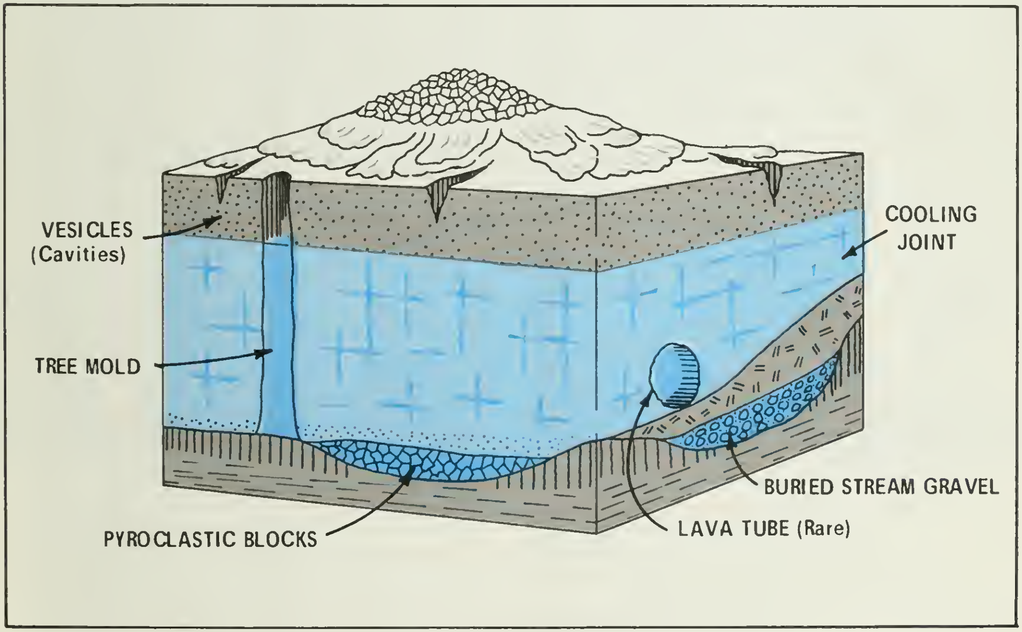


Figure 10. Ground Water in Volcanics

Highly Fractured Water-bearing Volcanics

Windmill and Water Storage Tank

Movement of Ground Water

Water moves underground in response to the same gravitational forces as does water on the surface. It moves toward the point of lowest water surface in the basin unless confined by some overlying material it cannot penetrate. The movement is very slow, usually less than 1,000 feet per year, because of the great amount of friction resulting from movement through the spaces between grains of sand or gravel. The low point is created by escape of water from the basin. The water may be entering an ocean, lake, or stream or may be appearing on the surface as a spring or seep. In California, the low point is most often created by pumping water from the basin through wells.

There is common exception to freedom of movement of water from the highest water surface to the lowest water surface in the basin (which sometimes differ from the highest and lowest land surface in the basin). This occurs when water becomes trapped under extensive clay layers that effectively prevent its upward movement. These layers often act much like a pipe in which water enters at a high point and is under pressure at the low end of the pipe. If the pressure is great enough toward the low end for water to rise above the ground surface, artesian flow occurs when the clay layers are penetrated by wells. Artesian flow is usually a short-lived situation. It doesn't take a great number of wells to decrease the pressure so that pumping is required to obtain desirable production.

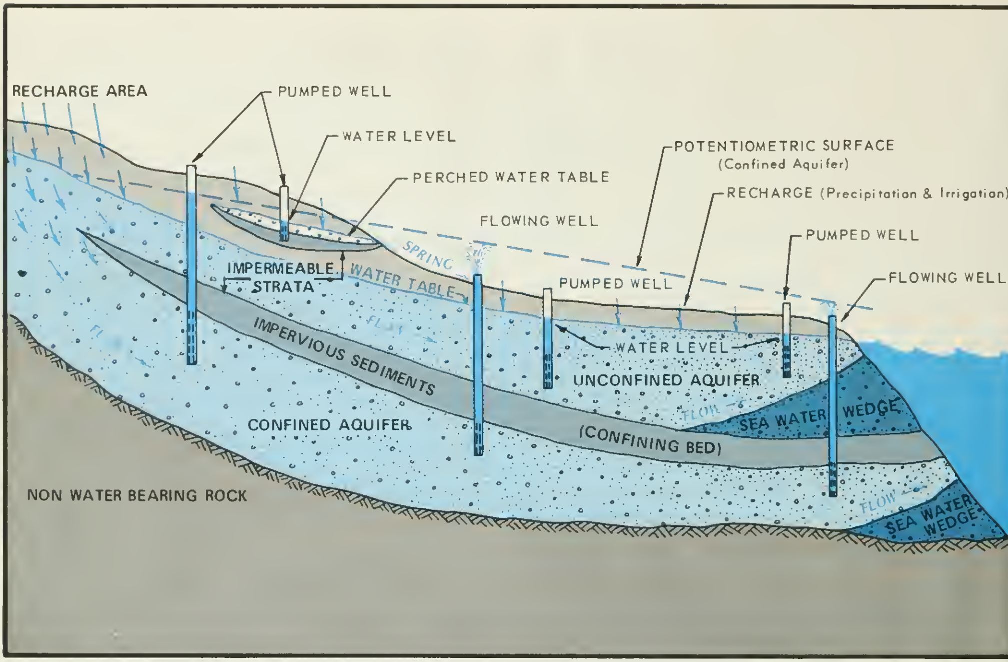


Figure 11. Unconfined and Confined Ground Water

In some ground water basins, bedrock lies at shallow depths and in some places faults cut through the basins. The shallow subsurface bedrock or the faults act as barriers to impede the movement of ground water. Commonly, where this occurs, the barrier acts as a dam, and water levels on the upstream side of the barriers are considerably closer to the land surface than are water levels on the downstream side.

The velocity of water in surface streams is measured in feet per second. Velocity of water moving in ground water basins is usually measured in feet per year. The cross-sectional area through which the water moves ranges from hundreds to thousands of feet in depth. The width is usually measured in miles. Therefore, despite the very low velocity, quite large quantities of water can move from one area of a ground water basin to another because the cross-section is so large. Because of this water movement, many ground water basins serve a very important role in distribution of water. The water flows underground from the locations where the basins can be recharged to the locations in the basin where the water is extracted. The ground water basin provides an economical natural substitute for extensive canal and pipeline surface distribution facilities.

In addition to the horizontal flow of ground water, vertical flow can occur, depending on the difference in hydraulic gradients between ground water bodies. Vertical flows become critical when poor-quality water can move upward or downward into fresh ground water bodies.

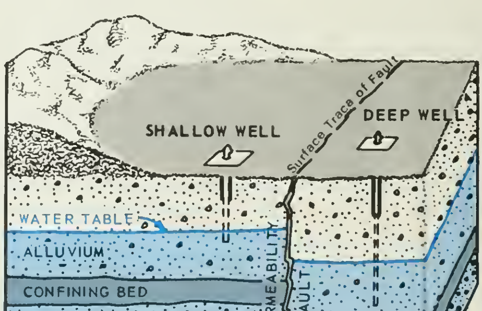


Figure 12. Effects of Faulting on Water Table

Quality of Ground Water

Water is one of the most effective solvents. It can hold in solution very large concentrations of some compounds and small concentrations of an exhaustive list of substances. These substances are generally classified as mineral compounds, such as sodium chloride (common table salt) or organic compounds such as oils or other plant or animal substances. Gases such as oxygen and nitrogen are also dissolved in water and have great importance to fish and plant life.

Rainfall contains very little dissolved material but begins to dissolve mineral and organic compounds as it flows across the surface of the earth. That portion that percolates through the soil to ground water basins dissolves materials even more rapidly, since it comes in contact with much greater surfaces of the soil and aquifer particles through which it percolates.

Water in ground water basins usually has a fairly low mineral content in the recharge areas and an increased content toward the point of discharge from the basin. Most mineral increases occur naturally or because of use and evaporation of water by plants. The unused water that returns to the ground water basin after an irrigation carries with it nearly all the salt contained in the original quantity of water. Most of the organic materials are added to the ground water through the use of water and disposal of wastes containing organic material. Water that has been in swamps, however, sometimes picks up large quantities of organic material from plants.

Common Minerals in Water

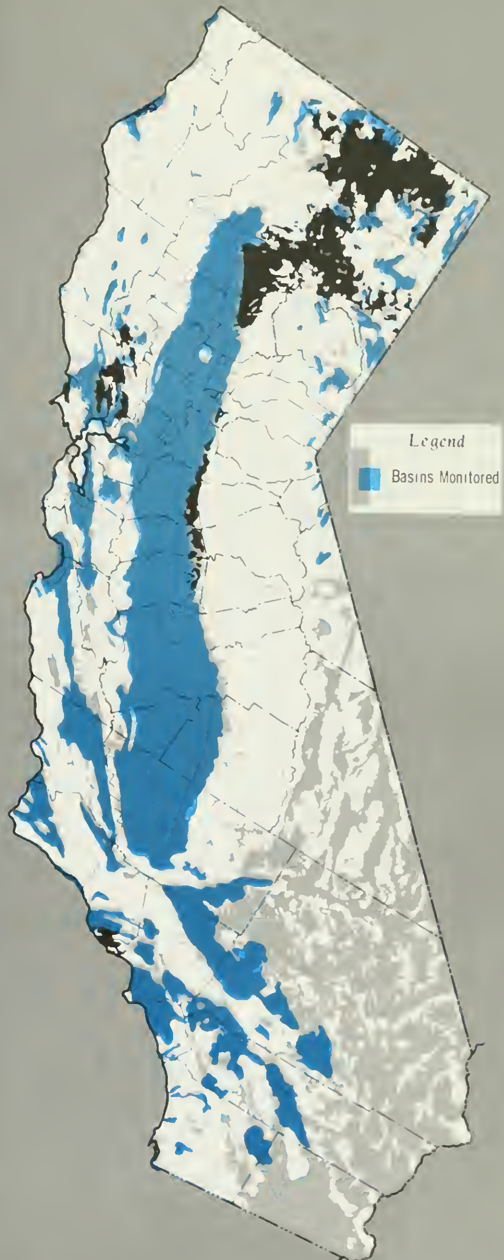


Figure 13. Basins Monitored by Department of Water Resources for Quality

Windmill—Stock Water Well

In some basins, poor quality or high temperature water, or both, occurs where faults cut through the water-bearing sediments.

Ground water basins frequently overlie or adjoin formations that contain salt water or sometimes discharge into the ocean or other salt water bodies below the surface of the salt water body. Salt water from such sources usually intrudes the fresh water aquifers when large quantities of the fresh water are pumped. Conversely, some of the confined fresh water aquifers in coastal regions extend seaward under the ocean floor for considerable distances without any evidence that sea water has intruded the aquifers.

Correction of water quality problems, or prevention of their occurrence, is a major portion of the task of managing ground water basins. This has led to realization that management of basins is as much concerned with maintenance of suitable quality as with development of the desired quantities of ground water. Fortunately, for the most part, the quality of the water in California's ground water basins is suitable for all beneficial uses.

The Role of Ground Water in California's Development

The first major influence of ground water on the development of California was to allow settlement at almost any location throughout the State where people wished to carry on mining, agriculture, or other enterprise. This was because of the wide-spread availability of sufficient ground water near the surface to supply a family and its livestock by simply digging a well or developing a spring.

Its second major influence was on irrigation early in this century, with the development of tools to bore large-capacity wells and the provision of electric power and efficient motors and pumps.

Domestic and Stock Water

The availability of ground water in dug wells or springs for domestic use also provided a health benefit for early California settlers. Purification of water as it percolates through soil and the granular media of aquifers minimizes the transfer of water-borne diseases. This is in marked contrast with the transmittal of diseases from one population to the next downstream users where people use untreated water from surface streams and return much of their wastes to such streams. These wastes in turn contaminate the water for the next downstream users. Polluted surface water was a major health problem for many early cultures and is still of major significance in undeveloped countries.

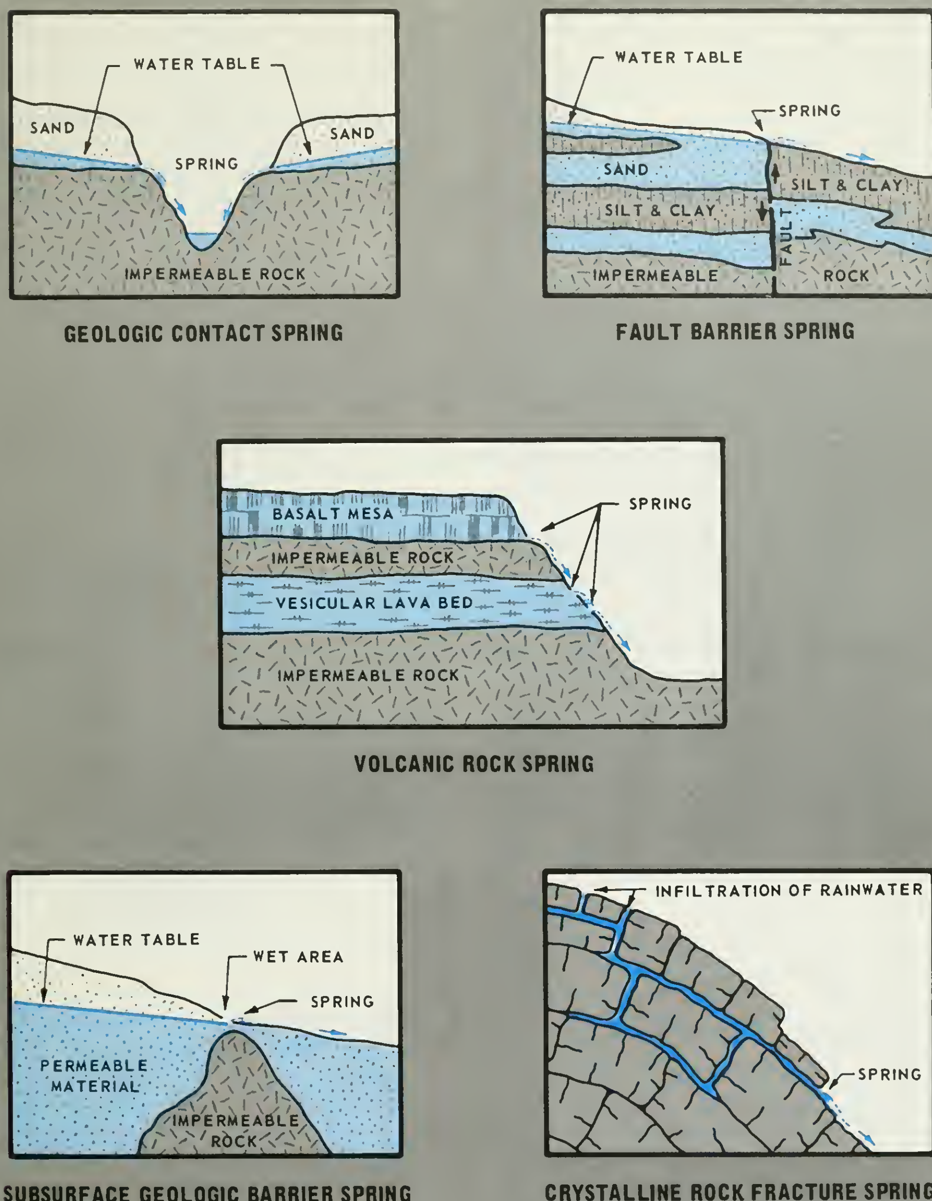
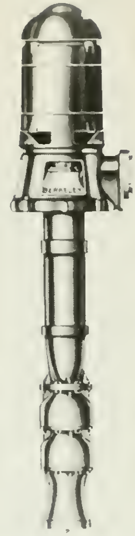


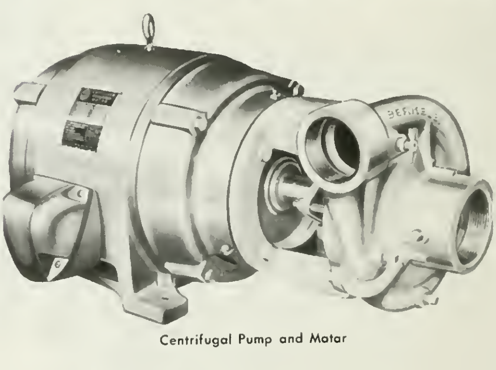
Figure 14. Springs


Rotary Well-drilling Rig in Operatian


Deep Well Turbine Pump and Motor


Deep Well Turbine Pump


Flowing Artesian Well—Stack and Irrigation Water Supply


Centrifugal Pump and Matar

Wells are often the most economic means of obtaining good quality water for domestic and municipal purposes in communities overlying ground water basins. Ground water is frequently used even when an alternative surface supply is available that could be treated and distributed. Stock water for large areas of rangeland is available from ground water through development of springs and from wells. The pumps at the wells are often powered by windmills.

Artesian Well Irrigation

Many ground water basins in California have aquifers that contain water under pressure. The pressure was sufficient to cause the water to rise to the surface of the ground and flow freely when wells first penetrated the aquifers. The pressure results from presence of overlying clay layers, some of which are very extensive. Water percolating in the upper portions of the basins flows under the relatively impermeable clay layers and creates substantial pressure in the lower portions of the basin. Development of motorized well-digging equipment around the turn of the century enabled wells to be drilled sufficiently deep to penetrate these aquifers and to make available substantial quantities of flowing artesian water for irrigation.

Centrifugal Pumps

During the early 1900s, the availability of both gasoline engines and electric power, as well as centrifugal pumps, enabled large quantities of water to be pumped from wells. There are still centrifugal pumps operating in pits, some, 20 feet or more in depth, in some areas in California. Such installations were fairly numerous in the early 1950s.

Deep Well Turbines

Development of deep-well turbine pumps and the increased availability of electrical power in agricultural areas in the 1920s led to widespread use of ground water for agriculture, even in areas where the water had to be pumped from depths of several hundred feet. In some instances, water was lifted as much as 1,000 feet. Use of ground water in the agricultural areas enabled individual farmers to irrigate large areas of land with relatively small capital outlay for water.

Use of similar wells by municipalities overlying ground water basins provided dependable supplies of municipal and industrial water for relatively large populations in areas with little or no summer streamflow.

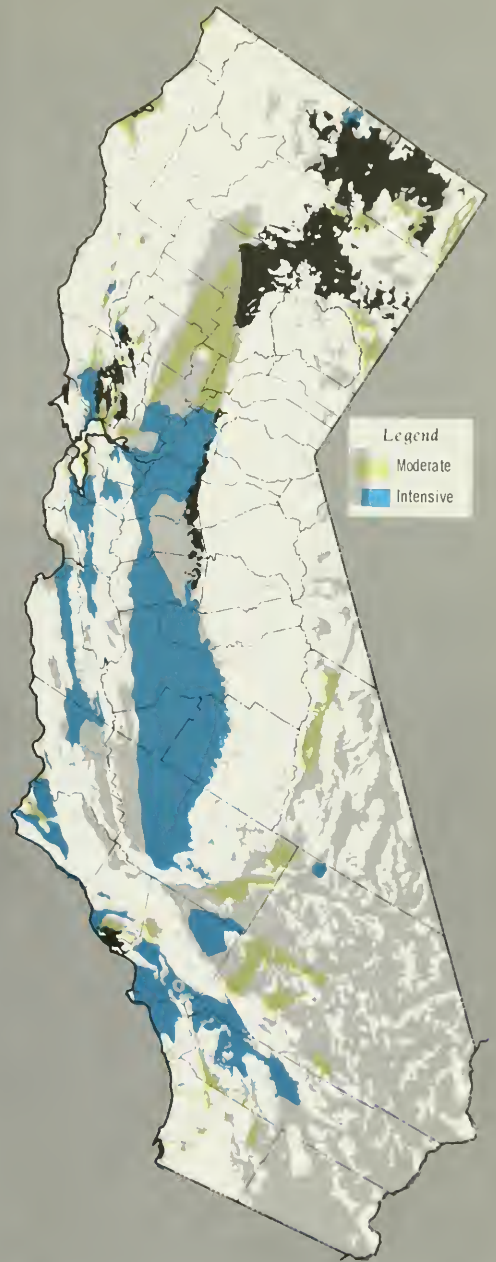


Figure 15. Ground Water Basins with Moderate or Intensive Development

Economy to Support Water Importation

Ground water development helped establish strong urban and agricultural economies. These economies were able to meet the large financial requirements to develop and import water from surface sources, often far distant from the ground water basin.

When the land area overlying a ground water basin is fully urbanized or fully devoted to irrigated agriculture, the water requirements usually exceed the recharge of the basin. Water levels fall, causing several problems for water users. Pumping costs increase, wells need to be deepened, and poor quality water sometimes enters wells.

These effects, along with the desire for a dependable water supply of known quality, often prompt the water users to import a supplemental supply.

One of the early import projects was the Los Angeles Aqueduct to bring water from the Owens Valley to Los Angeles.

Urban Area Overlying a Ground Water Basin

CHAPTER III. INVENTORY OF CALIFORNIA'S GROUND WATER RESOURCES

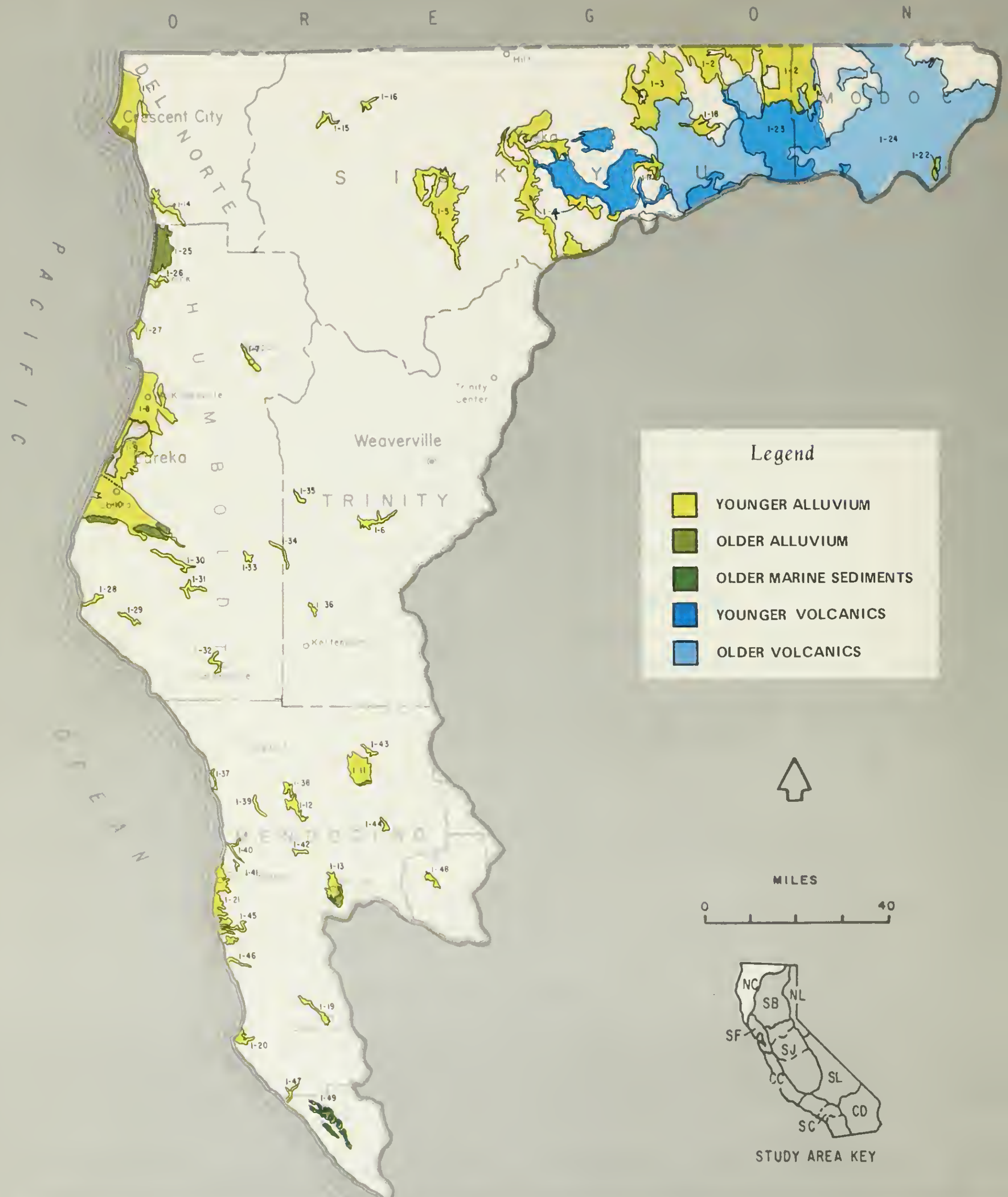
A small part of the information available on individual ground water basins in California is given in the following tabulations. Brief reference is made in the tabulations to the most informative reports on each basin. The complete reference is given in the bibliography at the end of this chapter.

For this inventory, the State has been divided into nine hydrologic study areas (HSA). A basin location map and brief summary of ground water conditions, in addition to data in the tabulation, are provided for each HSA.

Many of the definitions given in the glossary in Chapter II are used in the tabulation. Terms as defined in the following material are used in the tabulations to indicate the present level of knowledge for the basin in regard to geology, ground water hydrology, and water quality.

Evaluation	Degree of knowledge
	Geologic Criteria
Intensive.......	Detailed identification (names) and description of aquifers and detailed data on transmissivity (model)*
High..........	Detailed identification and description of aquifers but minimum data on transmissivity.
Moderate......	Moderate subsurface data available enabling the general description of aquifers and occasional naming.
Limited........	Limited subsurface data on free and confined water bodies.
Superficial......	Limited to knowledge that ground water occurs.
	Hydrologic Criteria
Intensive.......	Detailed information on recharge, occurrence, movement, disposal, and changes in storage (can model).
High..........	General information on recharge, occurrence, movement, and disposal.
Moderate......	Moderate information on occurrence and movement and recharge and disposal.
Limited........	Limited information on occurrence and movement based mainly on water level data.
Superficial......	Limited to knowledge that ground water occurs.
	Water Quality Criteria
Intensive.......	Detailed information on quantity and quality of all waters areally and analytical (model).
High.	General information on ground and surface water. Not enough data to show boundaries of different qualities of ground waters areally and/or vertically.
Moderate. .	Moderate information on ground and surface water. Data either highly clustered and/or spread out areally.
Limited.. . .	Limited information on ground and surface water areally and analytically.
Superficial......	Only that ground water is used for a particular purpose.

* Sufficient knowledge is available to develop and verify a mathematical model of the basin.



GROUND WATER BASINS - NORTH COASTAL HYDROLOGIC STUDY AREA

North Coastal Hydrologic Study Area

Ground Water Basins

No.	Old No.	Name	County
1-1	....	Smith River Plain	Del Norte
1-2	....	Klamath River Valley	Modoc, Siskiyou
1-3	....	Butte Valley	Siskiyou
1-4	....	Shasta Valley	Siskiyou
1-5	....	Scott River Valley	Siskiyou
1-6	....	Hayfork Valley	Trinity
1-7	....	Hoopa Valley	Humboldt
1-8	....	Mad River Valley	Humboldt
1-9	....	Eureka Plain	Humboldt
1-10	....	Eel River Valley	Humboldt
1-11	....	Round Valley	Mendocino
1-12	....	Laytonville Valley	Mendocino
1-13	....	Little Lake Valley	Mendocino
1-14	....	Lower Klamath River Valley	Del Norte
1-15	....	Happy Camp Town Area	Siskiyou
1-16	....	Seiad Valley	Siskiyou
1-17	....	Bray Town Area	Siskiyou
1-18	....	Red Rock Valley	Siskiyou
1-19	....	Anderson Valley	Mendocino
1-20	....	Garcia River Valley	Mendocino
1-21	....	Fort Bragg Terrace Area	Mendocino
1-22	....	Fairchild Swamp Valley	Modoc
1-23	....	Modoc Plateau Recent Volcanic Areas	Modoc, Siskiyou
1-24	....	Modoc Plateau Pleistocene Volcanic Areas	Modoc, Siskiyou
1-25	....	Prairie Creek Area	Humboldt
1-26	....	Redwood Creek Valley	Humboldt
1-27	....	Big Lagoon Area	Humboldt
1-28	....	Mattole River Valley	Humboldt
1-29	....	Honeydew Town Area	Humboldt
1-30	....	Pepperwood Town Area	Humboldt
1-31	....	Weott Town Area	Humboldt
1-32	....	Garberville Town Area	Humboldt
1-33	....	Larabee Valley	Humboldt
1-34	....	Dinsmores Town Area	Humboldt
1-35	....	Hyampom Valley	Trinity
1-36	....	Hettenshaw Valley	Trinity
1-37	....	Cottoneva Creek Valley	Mendocino
1-38	....	Lower Laytonville Valley	Mendocino
1-39	....	Branscomb Town Area	Mendocino
1-40	....	Ten Mile River Valley	Mendocino
1-41	....	Little Valley	Mendocino
1-42	....	Sherwood Valley	Mendocino
1-43	....	Williams Valley	Mendocino
1-44	....	Eden Valley	Mendocino
1-45	....	Big River Valley	Mendocino
1-46	....	Navarro River Valley	Mendocino
1-47	....	Gualala River Valley	Mendocino
1-48	....	Gravelly Valley	Lake
1-49	....	Anapolis Ohlson Ranch Formation Highlands	Sonoma

Summary

The North Coastal Hydrologic Study Area (HSA) comprises the coastal drainage basins of California north of the Russian River basin to the Oregon border. Principal streams are the Smith River, Klamath River, Trinity River, Redwood Creek, Mad River, Eel River, and Mattole River. The mean annual runoff from the HSA is about 28 million acre-feet. In some basins flowing wells and springs exist; notably, Big Springs near Granada in Siskiyou County flows at a perennial rate of 18,000 gallons per minute.

In this HSA, 49 ground water basins and areas of potential ground water storage have been identified. The inventory covers 14 ground water basins. These 14 basins, with a total area of about 2,000 square miles, have been identified as significant sources of ground water. The water-bearing deposits range in thickness up to slightly more than 2,000 feet. Estimated storage capacity for nine of the 14 basins is about 1.3 million acre-feet computed with varying thickness of water-bearing material from 25 to over 200 feet. Usable storage capacity for all nine basins has been estimated at about 800,000 acre-feet; the limiting factors are sea-water intrusion, aquifer materials of low permeability, thin alluvial deposits, and quality of water.

Ground water temperature ranges from about 48° to about 62° F. Total dissolved solids (TDS) content of the water is generally less than 500 mg/l, but in one location TDS exceeds 4,800 mg/l. The predominant water type is calcium bicarbonate, but magnesium, sodium, sulfate, and chloride are also found in some basins.

Properly constructed wells in the volcanic deposits in the Klamath River, Butte, and Shasta Valleys can yield as much as 4,000 gallons per minute.

Butte Valley is the most highly developed ground water basin in the HSA. In 1972 ground water pumpage was 63,000 acre-feet, which accounted for about 75 percent of the water supply. The basin is not in an overdraft condition.

Round Valley is not as well developed as Butte Valley; however, water users depend on the ground water basin for almost 100 percent of their water needs.

In the North Coastal HSA, which is an area of water surplus, ground water supplied about 140,000 acre-feet in 1972, or about 15 percent of the net annual demand of 940,000 acre-feet. The projected 2020 net annual demand for the HSA is about 1 million acre-feet, of which ground water is expected to supply 180,000 acre-feet, or about 18 percent of the total. Most of the increased pumping is expected in Butte Valley.

Recent (1970–71) data from Bulletin No. 63-5 indicate evidence of sea-water intrusion along the coast of the Eel River Valley. These data show chloride concentrations exceeding 100 mg/l in Redwood Creek Basin, Mad River Valley, and the Eureka Plain. However, all four areas are within the zone of tidal influence and are therefore subject to periodic intrusion. The main water-producing zones in the Mad River Valley, Eureka Plain and Eel River Valley are in the older alluvium (Hookton and Carlotta Formations). These formations are confined aquifers and show no evidence of sea-water intrusion.

Basin number	Basin name, county	Basin description: size, major stream, water bearing material	Well yields in gpm		Depth zone in feet	Storage capacity in acre-feet	Usable capacity in acre-feet
			Max.	Aver.			
1-1	Smith River Plain, Del Norte County	A 70-square-mile coastal basin drained by the Smith River. Younger alluvium.	500	50	10–35	100,000	75,000
1-2	Klamath River Valley, Modoc and Siskiyou Counties	A 720-square-mile basin drained by the Klamath River. Extends into Oregon. Younger alluvium and younger volcanics.	4000	1000	Unknown	Unknown	Unknown
1-3	Butte Valley, Siskiyou County	A 480-square-mile internal drained basin with outlet to Klamath River. Younger alluvium and older volcanics.	4000	2000	Unknown	Unknown	Unknown
1-4	Shasta Valley, Siskiyou County	A 340-square-mile basin drained by Shasta River. Younger alluvium and younger volcanics.	4000	1000	Unknown	Unknown	Unknown
1-5	Scott River Valley, Siskiyou County	A 80-square-mile basin drained by Scott River. Younger alluvium.	2500	1750	5–100	400,000	300,000
1-6	Hayfork Valley, Trinity County	A 6-square-mile basin drained by Hayfork Creek. Younger alluvium.	200	Unknown	0–25	3,500	1,500
1-7	Hoopa Valley, Humboldt County	A 5-square-mile basin drained by Trinity River. Younger alluvium	300	Unknown	10–40	19,000	9,500
1-8	Mad River Valley, Humboldt County	A 60-square-mile coastal basin drained by Mad River. Younger alluvium.	1,200	400	10–150	60,000	60,000
1-9	Eureka Plain, Humboldt County	A 60-square-mile coastal basin drained by several coastal streams. Younger alluvium.	1,200	400	Unknown	Unknown	Unknown
1-10	Eel River Valley, Humboldt County	A 120-square-mile coastal basin drained by the Eel and Van Duzen Rivers. Younger and older alluvium.	1,200	400	10–40	136,000	100,000
1-11	Round Valley, Mendocino County	A 23-square-mile basin drained by Mill Creek. Younger and older alluvium.	1,300	400	10–200	430,000	150,000
1-12	Laytonville Valley, Mendocino County	A 12-square-mile basin drained by Ten Mile and Outlet Creeks. Younger alluvium.	700	250	10–120	27,000	21,000

WATER RESOURCES
COASTAL
STUDY AREA

Development	Degree of knowledge	Problems
Moderate for irrigation, domestic, municipal, and stock use. Estimated 1968 pumpage 4,200 AF. Estimated safe yield 39,000 AFY. A potential for limited additional development in the south area and moderate development in the north area.	Limited for geology, hydrology, and water quality. References: DWR 61, 110; USGS 4	Low well yield in the south led to importation of water from the Smith River. Due to the shallow aquifer, danger of contamination with septic tank effluent exists. High iron content in some areas. Danger of seawater intrusion in northern part of basin.
Minor for domestic, irrigation and stock use. Estimated 1972 pumpage 13,000 AF. Estimated safe yield 24,000 AFY. A potential for limited additional development.	Limited for geology, eastern area, superficial for geology, western area. Limited in hydrology and water quality. References: DWR 45, 140; USGS 52	Ground water in the Klamath Lake area is generally high in sodium and nitrate content. Waters of poor quality are reported to occur in the upper water-bearing zones in the Tule Lake area.
Intensive for irrigation, domestic, and stock use. Estimated 1972 pumpage 63,000 AF. Sufficient ground water to meet projected 2020 water requirements of 92,000 AFY. A potential for limited additional development.	Moderate for geology. Limited for hydrology and water quality. References: DWR 70, 111; USGS 131	High sodium content in western portion of valley in the vicinity of Meiss Lake. Arsenic in shallow water in vicinity of Davis Creek. Temporary summer pumping overdraft caused by too many wells pumping at the same time.
Minor for irrigation—mostly for domestic and stock use. Estimated 1972 pumpage 9,000 AF. Estimated potential yield over 40,000 AFY. A potential for moderate to high additional development.	Limited for geology, hydrology, and water quality. References: DWR 72, 140; USGS 77	Some wells in north and central portion of valley yield high concentration of sodium, chloride, and boron. Wells near Lake Dwinnell produce water with high boron.
Minor for irrigation—mostly for domestic and stock use. Estimated 1975 pumpage 5,000 AF. Estimate potential yield over 36,000 AFY. A potential for moderate to high additional development.	Moderate for geology, limited for hydrology and water quality. References: DWR 45, 70, 140; USGS 76	Scattered shallow wells have high nitrates. Moffet Creek area has high sulfates.
Minor for domestic and industrial use. Estimated 1960 pumpage was about 300 AF. No potential for additional development.	Limited for geology, superficial for hydrology and water quality. References: DWR 45, 129	Thin alluvium and tight sediments—low yield. One deep well yielded water with high concentrations of sodium chloride. No other water quality problems are known.
Minor for domestic use—yields generally less than 10 gallons per minute. A potential for limited additional development.	Limited for geology, hydrology and water quality. References: DWR 129; USGS 107	Very thin alluvium—usually in the late summer and fall saturated thickness of alluvium is less than 5 feet—small yield. No known water quality problems.
Moderate for domestic, irrigation, industrial, and municipal use: mainly domestic. Estimated 1972 pumpage 9,000 AF. A potential for limited additional development.	Limited for geology, hydrology and water quality. References: DWR 129, 140, 188; USGS 38	Sea-water intrusion along the coast. Sanding of wells is a problem from the older Hookton Formation.
Moderate for domestic, irrigation, industrial, and municipal. Estimated 1972 pumpage 15,000 AF. A potential for limited additional development.	Limited for geology, hydrology and water quality. References: DWR 129, 140, 188; USGS 38	Sea-water intrusion along the coast. Sanding of wells is a problem from the older Hookton Formation. Scattered wells contain excessive iron. One deep well (375') produced high concentrations of boron and high percent sodium.
Moderate for domestic, irrigation, industrial, and municipal use. Estimated 1972 pumpage 10,000 AF. A potential for moderate additional development inland, limited near the coast.	Limited for geology, hydrology and water quality. References: DWR 129, 140, 188; USGS 38	Sea-water intrusion along the coast. High concentrations of iron basinwide generally.
Moderate for domestic, irrigation, industrial, and stock use. Ground water is essentially the only source of water for the valley. Estimated 1972 pumpage 5,000 AF. Estimated safe yield is about 30,000 AFY. A potential for moderate additional development.	Limited for geology, hydrology and water quality. References: DWR 47, 129, 140; USBR 3; USGS 18	Locally high in iron.
Moderate for domestic, irrigation, municipal, industrial, and stock use. Estimated 1972 pumpage 1,000 AF. Estimated safe yield about 10,000 AFY. A potential for moderate to high additional development.	Moderate for geology, limited for hydrology, and water quality. References: DWR 47, 129, USGS 18	Locally high in iron, sodium, and boron.

Basin number	Basin name, county	Basin description: size, major stream, water bearing material	Well yields in gpm		Depth zone in feet	Storage capacity in acre-feet	Usable capacity in acre-feet
			Max.	Aver.			
1-13	Little Lake Valley, Mendocino County	A 17-square-mile basin drained by Outlet Creek. Younger and older alluvium.	1,000	300	10–200	92,000	92,000
1-14	Lower Klamath River Valley, Del Norte County	A 12-square-mile coastal basin drained by Klamath River. Younger alluvium.	250	Unknown	Unknown	Unknown	Unknown

Development	Degree of knowledge	Problems
Moderate for domestic, irrigation, industrial, and stock use. Estimated 1972 pumpage 1,000 AF. Estimated safe yield 6,000 AFY. A potential for moderate additional development.	Moderate for geology, limited for hydrology and water quality. References: DWR 47, 129; USBR 12; USGS 18	Locally high in iron, manganese, and boron.
Minor for domestic and municipal use. A potential for moderate additional development in the gravel areas of the valley.	Superficial for geology, hydrology, and water quality. References: DWR 61	Thin alluvial deposits.

GROUND WATER BASINS - SAN FRANCISCO BAY HYDROLOGIC STUDY AREA

San Francisco Bay Hydrologic Study Area

Ground Water Basins

No.	Old No.	Name	County
2-1		Petaluma Valley	Marin, Sonoma
2-2		Napa-Sonoma Valley	Napa, Solano, Sonoma
2-2.01		Napa Valley	Napa, Solano
2-2.02		Sonoma Valley	Sonoma
2-3		Suisun-Fairfield Valley	Solano
2-4		Pittsburg Plain	Contra Costa
2-5		Clayton Valley	Contra Costa
2-6		Ygnacio Valley	Contra Costa
2-7		San Ramon Valley	Contra Costa
2-8		Castro Valley	Alameda
2-9		Santa Clara Valley	Alameda, Contra Costa, Santa Clara, San Mateo
2-9.01		East Bay Area	Alameda, Contra Costa
2-9.02		South Bay Area	Santa Clara
2-10		Livermore Valley	Alameda, Contra Costa
2-11		Sunol Valley	Alameda
2-12		McDowell Valley	Mendocino
2-13	1-22	Knights Valley	Sonoma
2-14	1-14	Potter Valley	Mendocino
2-15	1-15	Ukiah Valley	Mendocino
2-16	1-16	Sanel Valley	Mendocino
2-17	1-17	Alexander Valley	Sonoma
2-17.01	1-17.01	Alexander Area	Sonoma
2-17.02	1-17.02	Cloverdale Area	Sonoma
2-18	1-18	Santa Rosa Valley	Sonoma
2-18.01	1-18.01	Santa Rosa Plain	Sonoma
2-18.02	1-18.02	Healdsburg Area	Sonoma
2-18.03	1-18.03	Rincon Valley	Sonoma
2-19	1-23	Kenwood Valley	Sonoma
2-20	1-98	Lower Russian River Valley	Sonoma
2-21		Bodega Bay Area	Sonoma
2-22		Half Moon Bay Terrace	San Mateo
2-23		Napa-Sonoma Volcanics Highlands	Sonoma
2-24		San Gregorio Valley	San Mateo
2-25		Sebastopol Merced Formation Highlands	Marin, Sonoma
2-26		Pescadera Valley	San Mateo
2-27		Sand Point Area	Marin
2-28		Ross Valley	Marin
2-29		San Rafael Valley	Marin
2-30		Novato Valley	Marin
2-31		Arroyo del Hambre Valley	Contra Costa
2-32		Visitation Valley	San Francisco, San Mateo
2-33		Islais Valley	San Francisco
2-34		San Francisco Sand Dune Area	San Francisco
2-35		Merced Valley	San Francisco, San Mateo
2-36		San Pedro Valley	San Mateo

Summary

The San Francisco Bay Hydrologic Study Area (HSA) includes basins tributary to the San Francisco Bay, the Russian River drainage, and some minor basins along the coast in San Mateo County. In this HSA, 41 ground water basins, sub-basins, and areas of potential ground water storage have been identified. The inventory covers 26 ground water basins and sub-basins. These 26 basins, with a total area of about 1,700 square miles, have been identified as significant sources of ground water. The water-bearing deposits range in thickness up to 1,000 feet. There are flowing wells in several basins.

Estimated storage capacity for 19 of the basins is about 28.3 million acre-feet. Usable storage capacity of 15 basins has been estimated to be about 1.6 million acre-feet; factors limiting development are sea-water intrusion, aquifer materials of low permeability, and the quality of the water. Ground water temperatures generally range from about 50° to about 75°, but temperatures as high as 140°F have been recorded at Boyes Hot Springs in Sonoma Valley. TDS content of the water is generally less than 500 milligrams per liter, but a sample collected in Napa Valley had 11,700 milligrams per liter. The predominant water type is calcium-magnesium bicarbonate.

Properly constructed wells in some areas yield as much as 3,000 gallons per minute.

From basin to basin, the development of ground water for irrigation, domestic, industrial, and stock varies from minor to intensive. In 1972, ground water supplied 290,000 acre-feet, or about 24 percent of the HSA's net annual water demand. Of the projected 2020 water demand of about 2 million acre-feet, ground water is expected to supply 350,000 acre-feet, or about 17 percent (from Bulletin 160-74). Most of the increased pumping will occur in the South Bay area.

Sea-water intrusion in Alameda and Santa Clara Counties has been arrested by recharge programs. A well in the Alviso area in Santa Clara County was reported flowing this year (1975) after having stopped flowing many years ago. This shows the success of the Counties' program to refill the basin. Sea-water intrusion in Napa Valley, Sonoma Valley, and Pittsburg Plain has been arrested by using imported surface water and reducing ground water pumpage.

Knowledge of geology, hydrology, and water quality in many basins is limited. Two basins in which knowledge is adequate are Livermore and Santa Clara Valleys. Studies are currently being conducted in Sonoma, Alameda, and Santa Clara Counties.

Basin number	Basin name, county	Basin description: size, major stream, water bearing material	Well yields in gpm		Depth zone in feet	Storage capacity in acre-feet	Usable capacity in acre-feet
			Max.	Aver.			
2-1	Petaluma Valley, Marin and Sonoma Counties.	A 41-square-mile basin drained by Petaluma Creek. Younger and older alluvium.	650	40	0–900	2,100,000	Unknown
2-2	Napa-Sonoma Valley						
2-2.01	Napa Valley, Napa and Solano Counties.	A 230-square-mile basin drained by Napa River. Younger and older alluvium, and older volcanics and sediments.	3,000	200	10–200	300,000	Unknown
2-2.02	Sonoma Valley, Sonoma County.	A 50-square-mile basin drained by Sonoma Creek. Younger and older alluvium, and older volcanics and sediments.	400	Unknown	0–1,000	2,660,000	Unknown
2-3	Suisun-Fairfield Valley, Solano County.	A 260-square-mile basin drained by Green Valley, Suisun, Ledgewood and Laurel Creeks. Younger and older alluvium, and older volcanics and sediments.	1,000	150	10–200	226,000	40,000
2-4	Pittsburg Plain, Contra Costa County.	A 30-square-mile basin drained by New York Slough. Younger and older alluvium.	Unknown	Unknown	Unknown	Unknown	Unknown
2-5	Clayton Valley, Contra Costa County.	A 30-square-mile basin drained by Walnut Creek. Younger alluvium.	Unknown	Unknown	20–200	180,000	80,000
2-6	Ygnacio Valley, Contra Costa County.	A 30-square-mile basin drained by Walnut Creek. Younger alluvium.	500	200	20–200	200,000	50,000
2-7	San Ramon Valley, Contra Costa County.	A 30-square-mile basin drained by Ramon Creek. Younger alluvium.	Unknown	Unknown	Unknown	Unknown	Unknown
2-8	Castro Valley, Alameda County.	A 4-square-mile basin drained by San Lorenzo Creek. Younger alluvium.	Unknown	Unknown	Unknown	Unknown	Unknown
2-9	Santa Clara Valley, Alameda, Contra Costa, San Mateo and Santa Clara Counties (Includes 2-9.01 East Bay area and 2-9.02 South Bay area).	A 580-square-mile basin drained by Guadalupe River, and Alameda, Coyote, Redwood and San Francisquito Creeks. Younger and older alluvium.	1,650	425	10–1010	12,200,000	Unknown
2-10	Livermore Valley, Alameda and Contra Costa Counties.	A 170-square-mile basin drained by Arroyo de la Laguna. Younger and older alluvium.	2,800	400	0–500	540,000	200,000
2-11	Sunol Valley, Alameda County.	A 20-square-mile basin drained by Alameda Creek. Younger and older alluvium.	Unknown	Unknown	Unknown	Unknown	Unknown

WATER RESOURCES
HYDROLOGIC STUDY AREA

Development	Degree of knowledge	Problems
Intensive for domestic and moderate for stock watering, municipal, irrigation, and industrial use. A potential for moderate additional development.	Moderate for geology. Limited for hydrology and water quality. References: DWR 48, 123, 144, 185; USGS 16, 17	Hard water, high chloride and TDS. Any appreciable increase in ground water draft in the bayward segment will result in sea-water intrusion.
Moderate to intensive for domestic, irrigation, municipal, and industrial use. Estimated 1970 pumpage for northern Napa Valley 5,700 AF. Pumpage can be increased to 24,000 AF without significant decline of the water levels. A potential for moderate additional development.	Moderate for geology north half and limited south half. Moderate for hydrology. Limited for water quality. References: DWR 48, 185; USGS 41, 62	Sea-water intrusion arrested by imported water via Putah South Canal and North Bay Aqueduct. Presence of connate water in deeper aquifers. Locally high iron, chloride, and boron.
Moderate to intensive for domestic and limited for municipal, industrial and irrigation use. Estimated 1950 pumpage 2,400 AF. A potential for moderate additional development.	Moderate for geology. Limited for hydrology and water quality. References: DWR 48, 123; USGS 62	High TDS and hard water in bayward portion.
Moderate for irrigation, domestic, stock and industrial use. Estimated 1971 pumpage 3,800 AF. Estimated safe yield about 6,000 AF. A potential for limited additional development.	Moderate for geology. Limited for hydrology and water quality. References: DWR 179; USBR 6; USGS 84, 116	High boron and hard water. Heavy pumping in the southern part of basin may cause brackish water to move inland degrading the ground water quality.
Intensive industrial pumpage in 1930's caused overdraft. Use of Contra Costa Canal water ceased overdraft. 1969 pumpage 1,200 AF. A potential for limited additional development.	Moderate for geology. Limited for hydrology and water quality. References: DWR 55, 179; USGS 3	Sea-water intrusion was a problem from 1930 until the 1950's when the Contra Costa Canal was operating. In 1955 an apparent bayward hydraulic gradient was established and flushing of the saline water began. The exact location and extent of degraded ground water in this basin was not known in 1971.
Intensive for irrigation, domestic, stock, and industrial use. A potential for limited additional development.	Limited for geology in coastal area, superficial inland. Limited for hydrology and water quality. References: DWR 55, 145, 179; USGS 3	Sea-water intrusion same as described in Pittsburg Plain, Basin 2-4.
Limited for irrigation, domestic, stock, and industrial use. A potential for limited additional development.	Limited for geology, hydrology, and water quality. References: DWR 55, 179, 185; Misc. 10	Sea-water intrusion same as described in Pittsburg Plain, Basin 2-4. High ground water table.
Intensive for irrigation, domestic, and stock use. A potential for limited additional development.	Superficial for geology, hydrology, and water quality. References: DWR 179; USGS 10	None known.
Limited for irrigation, domestic, and stock use. A potential for limited additional development.	Superficial for geology, hydrology, and water quality. References: DWR 60, 179; USGS 10	None known.
Intensive for domestic, industrial, and irrigation use. Irrigation pumpage in Santa Clara County declined since 1965 due to levying of a ground water pump tax. Artificial recharging program in Alameda and Santa Clara Counties. Estimated 1970 pumpage 250,000 AF. A potential for limited additional development.	High to intensive for geology in most of basin. Moderate for hydrology and water quality. References: DWR 4, 10, 69, 116, 117, 118, 119; USBR 1, 9; USGS 105	Sea-water intrusion in Fremont and San Jose areas. Sea-water intrusion arrested by recharge program. Land subsidence due to overdraft. Subsidence has been arrested by the recharge program.
Intensive for domestic, industrial, and irrigation use. 1970 pumpage 27,000 AF. Estimated safe yield 27,000 AF. A potential for limited additional development.	High for geology, hydrology, and water quality. References: DWR 10, 120, 121, 153	Poor quality water occurs in eastern part of valley and near Dublin—high TDS, chloride, and boron. Generally water is hard requiring softening for domestic use.
Limited for domestic use. Water collected in galleries and exported by San Francisco Water Department. A potential for limited additional development.	Moderate for geology. Limited for hydrology and water quality. References: DWR 120, 121, 177, 179	Areas with high TDS.

Basin number	Basin name, county	Basin description: size, major stream, water bearing material	Well yields in gpm		Depth zone in feet	Storage capacity in acre-feet	Usable capacity in acre-feet
			Max.	Aver.			
2-13 (1-22)*	Knights Valley, Sonoma County	A 5-square-mile basin drained by Redwood Creek. Younger alluvium.	Unknown	Unknown	10–110	17,000	17,000
2-14 (1-14)	Potter Valley, Mendocino County	A 13-square-mile basin drained by East Fork of Russian River. Younger and older alluvium.	70	30	0–200	71,000	9,000
2-15 (1-15)	Ukiah Valley, Mendocino County	A 16-square-mile basin drained by the Russian River. Younger and older alluvium.	1,600	400	0–200	369,000	35,000
2-16 (1-16)	Sanel Valley, Mendocino County	A 11-square-mile basin drained by the Russian River. Younger alluvium.	1,200	500	0–100	51,700	20,000
2-17 2-17.01 (1-17.01)	Alexander Valley Alexander Area, Sonoma County	A 23-square-mile basin drained by the Russian River. Younger and older alluvium.	450	130	0–470	445,000	60,000
2-17.02 (1-17.02)	Cloverdale Area, Sonoma County	A 9-square-mile basin drained by the Russian River. Younger alluvium.	450	130	0–100	50,000	15,000
2-18 2-18.01 (1-18.01)	Santa Rosa Valley Santa Rosa Plain, Sonoma County	A 96-square-mile basin drained by Santa Rosa Creek. Younger and older alluvium, and older volcanics and sediments.	1,500	90	0–1000	7,100,000	950,000
2-18.02 (1-18.02)	Healdsburg Area, Sonoma County	A 27-square-mile basin drained by the Russian River. Younger and older alluvium.	1,000	180	0–250	930,000	67,000
2-18.03 (1-18.03)	Rincon Valley, Sonoma County	A 4-square-mile basin drained by Rincon Creek. Younger and older alluvium.	Unknown	Unknown	0–1000	290,000	18,000
2-19 (1-23)	Kenwood Valley, Sonoma County	A 6-square-mile basin drained by Santa Rosa and Sonoma Creeks. Younger and older alluvium, and older volcanics and sediments.	Unknown	Unknown	0–1000	460,000	27,000
2-20 (1-98)	Lower Russian River Valley, Sonoma County	A 9-square-mile coastal basin drained by the Russian River. Younger alluvium.	Unknown	Unknown	0–300	160,000	22,000
2-22	Half Moon Bay Terrace, San Mateo County	A 25-square-mile coastal basin drained by Pilarcitos Creek. Younger alluvium including an extensive marine terrace.	Unknown	Unknown	Unknown	Unknown	Unknown
2-24	San Gregorio Valley, San Mateo County	A 10-square mile coastal basin drained by San Gregorio Creek. Younger alluvium.	Unknown	Unknown	Unknown	Unknown	Unknown
2-26	Pescadero Valley, San Mateo County	A 8-square-mile coastal basin drained by Pescadero Creek. Younger alluvium.	Unknown	Unknown	Unknown	Unknown	Unknown

* Old number

Development	Degree of knowledge	Problems
Limited for domestic and stock use. A potential for moderate additional development.	Moderate for geology. Limited for hydrology and water quality. References: DWR 123, 129	None known.
Limited for irrigation generally for domestic and stock use. A potential for limited additional development.	Limited for geology, hydrology, and water quality. References: DWR 47, 129, 185, 189, USGS 16, 18	Low yields. Fairly hard for domestic use and often contains objectionable concentrations of iron.
Intensive for domestic, irrigation, industrial, and municipal use. Estimated 1954 pumpage 10,000 AF. A potential for limited additional development.	Limited for geology, hydrology, and water quality. References: DWR 47, 129, 185, 189, USGS 16, 18	Generally good quality. Some with poor quality high boron.
Moderate for irrigation and domestic use. A potential for limited additional development.	Limited for geology, hydrology, and water quality. References: DWR 47, 129, 185, 189; USGS 16, 18	High boron and iron.
Moderate for irrigation, domestic, industrial, and stock use. Estimated 1954 pumpage 3,000 AF. A potential for moderate additional development	Moderate for geology. Limited for hydrology and water quality. References: DWR 123, 129, 189; USGS 16, 18	Water hard for domestic use.
Moderate for irrigation, domestic, industrial, and stock use. A potential for limited additional development.	Moderate for geology. Limited for hydrology and water quality. References: DWR 123, 129; USGS 18	Moderately hard water for domestic use.
Intensive for municipal, industrial and irrigation use. A potential for moderate additional development.	Moderate for geology. Limited for hydrology and water quality. References: DWR 123, 129, 132, 144; USGS 17	Areas with TDS greater than 500 mg/1, and hard water.
Moderate for irrigation, domestic, industrial, and stock use. A potential for moderate additional development.	Moderate for geology. Limited for hydrology and water quality. References: DWR 123, 129; USGS 17	Moderately hard water.
Moderate for irrigation, domestic and stock use. A potential for limited additional development.	Moderate for geology. Limited for hydrology and water quality. References: DWR 123, 129; USGS 17	Areas of high TDS and hardness.
Limited for domestic and stock use. A potential for moderate additional development.	Moderate for geology. Limited for hydrology and water quality. References: DWR 123, 129	Moderately hard water.
Limited for domestic use. A potential for limited additional development.	Moderate for geology. Limited for hydrology and water quality. References: DWR 123, 129; USGS 18	Hard water, high chloride and TDS. Sea-water intrusion near the coast.
Limited for domestic use and irrigation of parks, golf courses and cemeteries. Standby for municipal and a few industrial wells. A potential for limited additional development.	Moderate for geology north area, limited south area. Limited for hydrology and water quality References: DWR 55, 128, 179; Misc. 6	Poor quality water along the coast, may be local ground water condition of the marine terrace deposits rather than seawater intrusion. Moderate to high TDS.
Moderate for domestic, irrigation and stock use. Small ground water pumpage in the order of 300 AF per year. A potential for limited additional development.	Superficial for geology, hydrology and water quality. References: DWR 55, 129, 179	Poor quality water along the coast, may be local ground water condition of the alluvium rather than sea-water intrusion. High TDS.
Moderate for irrigation, domestic and stock use. A potential for limited additional development.	Superficial for geology, hydrology and water quality. References: DWR 55, 128	Tidal area showed seawater intrusion from sample taken in 1970.

GROUND WATER BASINS - CENTRAL COASTAL HYDROLOGIC STUDY AREA

CENTRAL COASTAL HYDROLOGIC STUDY AREA

Ground Water Basins

No.	Old No.	Name	County
3-1	....	Soquel Valley	Santa Cruz
3-2	....	Pajaro Valley	Monterey, Santa Cruz
3-3	....	Gilroy-Hollister Valley	San Benito, Santa Clara
3-4	....	Salinas Valley	Monterey
3-4.06	....	Paso Robles Basin	Monterey, San Luis Obispo
3-4.08	....	Seaside Area	Monterey
3-4.09	....	Langley Area	Monterey
3-4.10	....	Corral de Tierra Area	Monterey
3-5	....	Cholame Valley	Monterey, San Luis Obispo
3-6	....	Lockwood Valley	Monterey
3-7	....	Carmel Valley	Monterey
3-8	....	Los Osos Valley	San Luis Obispo
3-9	....	San Luis Obispo Valley	San Luis Obispo
3-10	....	Pismo Creek Valley	San Luis Obispo
3-11	....	Arroyo Grande Valley-Nipoma Mesa Area	San Luis Obispo
3-12	....	Santa Maria River Valley	San Luis Obispo, Santa Barbara
3-13	....	Cuyama Valley	Kern, San Luis Obispo, Santa Barbara, Ventura
3-14	....	San Antonio Creek Valley	Santa Barbara
3-15	....	Santa Ynez River Valley	Santa Barbara
3-16	....	Goleta Basin	Santa Barbara
3-17	....	Santa Barbara Basin	Santa Barbara
3-18	....	Carpinteria Basin	Santa Barbara
3-19	....	Carrizo Plain	San Luis Obispo
3-20	....	Ano Nuevo Area	San Mateo
3-21	....	Santa Cruz Purisima Formation Highlands	Santa Cruz
3-22	....	Santa Ana Valley	San Benito
3-23	....	Upper Santa Ana Valley	San Benito
3-24	....	Quien Sabe Valley	San Benito
3-25	....	Tres Pinos Creek Valley	San Benito
3-26	....	West Santa Cruz Terrace	Santa Cruz
3-27	....	Scotts Valley	Santa Cruz
3-28	....	San Benito River Valley	San Benito
3-29	....	Dry Lake Valley	San Benito
3-30	....	Bitter Water Valley	San Benito
3-31	....	Hernandez Valley	San Benito
3-32	....	Peach Tree Valley	San Benito
3-33	....	San Carpoforo Valley	San Luis Obispo
3-34	....	Arroyo de la Cruz Valley	San Luis Obispo
3-35	....	San Simeon Valley	San Luis Obispo
3-36	....	Santa Rosa Valley	San Luis Obispo
3-37	....	Villa Valley	San Luis Obispo
3-38	....	Cayucos Valley	San Luis Obispo
3-39	....	Old Valley	San Luis Obispo
3-40	....	Toro Valley	San Luis Obispo
3-41	....	Morro Valley	San Luis Obispo
3-42	....	Chorro Valley	San Luis Obispo
3-43	....	Rinconada Valley	San Luis Obispo
3-44	....	Pozo Valley	San Luis Obispo
3-45	....	Huasna Valley	San Luis Obispo
3-46	....	Rafael Valley	San Luis Obispo
3-47	....	Big Spring Area	San Luis Obispo
3-48	....	Careaga Sand Highlands	Santa Barbara
3-49	....	Montecito Area	Santa Barbara

Summary

The Central Coastal Hydrologic Study Area (HSA) comprises the coastal drainage basins between the western end of Ventura County on the south and the southern end of San Mateo County on the north. In this HSA, 53 ground water basins, sub-basins and areas of potential ground water storage have been identified. The inventory covers 22 ground water basins and sub-basins. These 22 basins, with a total area of about 3,300 square miles, have been identified as significant sources of ground water. Water-bearing deposits exceed 2,300 feet in thickness in Santa Maria River Valley. There are flowing wells in several basins.

Estimated storage capacity for 18 valleys is about 25.2 million acre-feet. Usable storage capacity of 16 valleys is estimated to be about 6.9 million acre-feet. The principal factor limiting development of ground water in the HSA is sea-water intrusion.

Ground water temperature ranges from about 55° to about 75° F. The TDS content of the water is generally less than 800 milligrams per liter, but locally is more than 11,000 milligrams per liter. The predominant water type is calcium bicarbonate; however, sodium, magne-

INVENTORY OF GROUND
CENTRAL COASTAL

Basin number	Basin name, county	Basin description: size, major stream, water bearing material	Well yields in gpm		Depth zone in feet	Storage capacity in acre-feet	Usable capacity in acre-feet
			Max.	Aver.			
3-1	Soquel Valley, Santa Cruz County	A 7-square-mile coastal basin drained by Soquel Creek. Younger alluvium and older marine sediments.	800	350	Unknown	800,000	Unknown
3-2	Pajaro Valley, Monterey and Santa Cruz Counties	A 120-square-mile coastal basin drained by the Pajaro River. Younger alluvium.	1,200	500	Unknown	Unknown	Unknown
3-3	Gilroy-Hollister Valley, San Benito and Santa Clara Counties	A 350-square-mile basin drained by the Pajaro River. Younger and older alluvium.	1,700	400	20–200	932,000	800,000
3-4	Salinas Valley, Monterey County	A 620-square-mile coastal basin drained by the Salinas River. Younger and older alluvium.	3,750	750	20–200	3,500,000	1,300,000
3-4.06	Paso Robles Basin (Upper Salinas Valley), Monterey and San Luis Obispo Counties	A 860-square-mile basin drained by the Salinas River. Younger and older alluvium.	3,300	500	50–250	6,800,000	1,700,000
3-5	Cholame Valley, Monterey and San Luis Obispo Counties	A 20-square-mile basin drained by Cholame Creek. Younger and older alluvium.	3,300	1,000	Unknown	Unknown	Unknown
3-6	Lockwood Valley, Monterey County	A 90-square-mile basin drained by the San Antonio River. Younger and older alluvium.	3,300	1,000	20–230	1,000,000	500,000
3-7	Carmel Valley, Monterey County	A 10-square-mile coastal basin drained by the Carmel River. Younger alluvium.	Unknown	600	0–160	60,000	Unknown
3-8	Los Osos Valley, San Luis Obispo County	A 20-square-mile coastal basin drained by Los Osos, Chorro, and Morro Creeks. Younger alluvium.	700	230	10–200	112,200	14,700

sium, sulfate, and chloride are present locally in significant quantities.

Properly constructed wells in some areas can yield as much as 4,400 gallons per minute.

About 90 percent of the water supply in the HSA comes from ground water. There is potential for limited additional development in most of the ground water basins.

The most intensively developed ground water basin is the lower Salinas Valley in Monterey County, where about 95 percent of the water supply is ground water. Sea-water intrusion was first noticed in the late 1930s and early 1940s when several wells in a shallow 180-foot-aquifer were abandoned because of high salt content. Degradation of the 180-foot aquifer led to development of a deeper 400-foot aquifer, and subsequent degradation of the coastal portion of this deep aquifer.

As of 1973 both aquifers showed evidence of intrusion. During that year, water with a chloride concentration of 100 milligrams per liter was found 4 miles inland in the 180-foot aquifer and 2 miles inland in the 400-foot aquifer. Since 1950, the intrusion rate in the 180-foot aquifer has been about 0.1 mile per year. Intrusion in the Salinas Valley can be controlled by reducing ground water pumping in the pressure area, roughly from Spreckels to Monterey Bay.

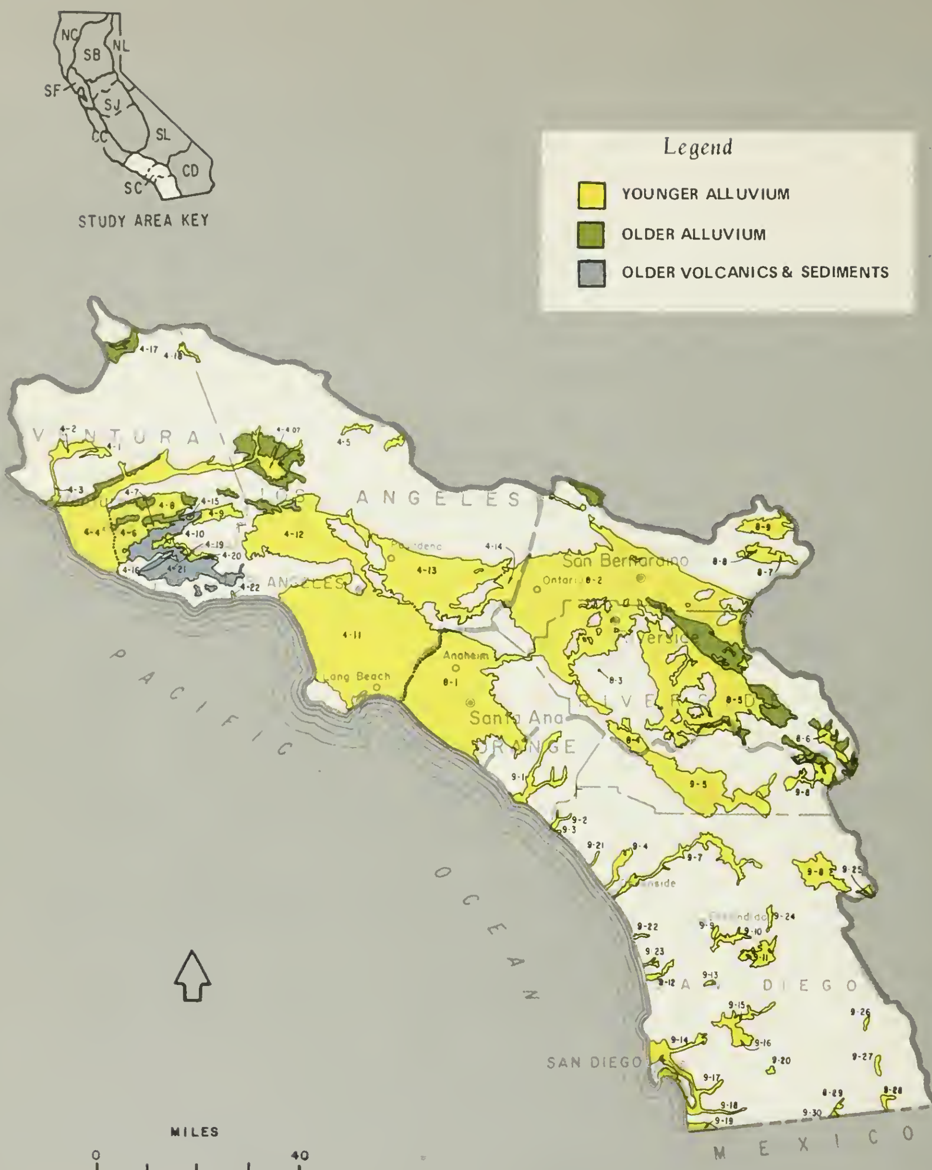
WATER RESOURCES
HYDROLOGIC STUDY AREA

Development	Degree of knowledge	Problems
Moderate for irrigation, domestic, and municipal use. 1966 pumpage about 3,300 AF. A potential for limited additional development.	Moderate for geology, limited for hydrology and water quality. References: DWR 2, 55; USGS 2, 8, 49	No apparent sea-water intrusion in 1955. Sea-water intrusion reported by USGS in 1969. High TDS, iron, and hardness.
Intensive for irrigation, domestic, stock, industrial, and municipal use. Estimated 1971 pumpage 62,000 AF. Estimated safe yield is 44,000 AFY. No further development potential.	High for geology. Moderate for hydrology and water quality. References: DWR 2, 151, 152; USBR 1; USGS 92, 93	Sea-water intrusion area had increased 1 mile inland by 1947, 1.4 mile by 1962 and 1.6 mile inland by 1970. Water quality usually poor with high TDS, nitrates, and hardness.
Intensive for irrigation, domestic, stock and industrial use. Estimated 1972 pumpage 128,000 AF. No further development potential.	Moderate for geology except in San Juan Valley area. Moderate for hydrology and water quality. References: DWR 140, 177, 178; USBR 1; USGS 42, 58	High TDS and boron. Overdraft condition exists.
Intensive for irrigation, domestic, stock and industrial use. Estimated 1972 pumpage 336,000 AF. No further development potential.	Moderate for geology in coastal area, limited inland. Moderate for hydrology and water quality. References: DWR 14, 55, 140, 151, 152, 172, 176; USGS 45	Sea-water intrusion area increasing. Both the "180-foot" and "400-foot" aquifers intruded. In the "180-foot" aquifer, chloride concentration of 500 mg/l and 100 mg/l extend inland 3.5 and 4 miles, respectively. The intrusion rate of 0.1 mile per year has occurred since 1950. Intrusion in the "400-foot" aquifer is about 2 miles inland fairly stationary since 1954. High TDS and hardness.
Intensive for irrigation use and moderate for municipal use. Limited for industrial, domestic and stock use. Recharge estimated at 47,000 AFY. 1967 extractions about 48,000 AF. A potential for moderate additional development.	Limited for geology, hydrology, and water quality. References: DWR 13, 140, 157, 162, 167; USGS 28	Locally boron high for irrigation use.
Limited for domestic, irrigation, and stock use. A potential for limited additional development.	Superficial for geology, hydrology and water quality. References: DWR 13, 185	None known.
Limited for irrigation, domestic and stock use. A potential for moderate additional development.	Superficial for geology, hydrology and water quality. References: DWR 148	Hard water.
Moderate for domestic, irrigation, and stock use. Estimated 1973 pumpage 6,200 AF. Estimated sustained annual yield is about 15,000 AF. A potential for moderate additional development.	Moderate for geology, hydrology and water quality. References: DWR 171	Moderate TDS and hard water, high iron and manganese.
Moderate for irrigation and municipal use. Limited for industrial and domestic use. A potential for limited additional development.	Moderate for geology, hydrology and water quality. References: DWR 13, 56, 167, 169	Locally chloride high for domestic and irrigation uses. Sea-water intrusion.

Basin number	Basin name, county	Basin description: size, major stream, water bearing material	Well yields in gpm		Depth zone in feet	Storage capacity in acre-feet	Usable capacity in acre-feet
			Max.	Aver.			
3-9	San Luis Obispo Valley, San Luis Obispo County	A 15-square-mile basin drained by San Luis Obispo Creek. Younger alluvium.	600	300	20–160	67,000	22,000
3-10	Pismo Creek Valley, San Luis Obispo County	A 10-square-mile coastal basin drained by Pismo Creek. Younger alluvium.	500	350	10–110	30,000	10,000
3-11	Arroyo Grande Valley-Nipomo Mesa Area, San Luis Obispo County	A 40-square-mile coastal basin drained by Arroyo Grande Creek. Younger and older alluvium.	2,500	300	100–800	1,700,000	40,000 (Arroyo Grande Valley only)
3-12	Santa Maria River Valley, San Luis Obispo and Santa Barbara Counties	A 200-square-mile coastal basin drained by the Santa Maria River. Younger and older alluvium.	2,200	1,000	20–200	2,000,000	1,000,000
3-13	Cuyama Valley, Kern, San Luis Obispo, Santa Barbara, and Ventura Counties	A 230-square-mile basin drained by the Cuyama River. Younger and older alluvium.	4,400	1,100	100–300	2,100,000	400,000
3-14	San Antonio Creek Valley, Santa Barbara County	A 90-square-mile coastal basin drained by San Antonio Creek. Younger and older alluvium, and older marine sediments.	Unknown	400	50–250	2,100,000	300,000
3-15	Santa Ynez River Valley, Santa Barbara County	A 260-square-mile coastal basin drained by the Santa Ynez River. Younger and older alluvium, and older marine sediments.	1,300	750	20–250	2,700,000	362,000
3-16	Goleta Basin, Santa Barbara County	A 16-square-mile coastal basin drained by Atascadero Creek. Younger alluvium.	800	500	50–250	180,000	17,000
3-17	Santa Barbara Basin, Santa Barbara County	A 15-square-mile coastal basin drained by Sycamore Creek. Younger alluvium.	1,000	500	50–250	550,000	281,000
3-18	Carpinteria Basin, Santa Barbara County	A 12-square-mile coastal basins drained by Santa Monica, Steer and Rincon Creeks. Younger alluvium.	500	300	50–250	140,000	19,000
3-19	Carrizo Plain, San Luis Obispo County	A 270-square-mile basin with internal drainage. Younger and older alluvium.	1,000	500	30–230	400,000	100,000
3-26	West Santa Cruz Terrace, Santa Cruz County	A 6-square-mile coastal area west of Santa Cruz. Extensive marine terrace.	Unknown	Unknown	Unknown	Unknown	Unknown
3-27	Scotts Valley, Santa Cruz County	A 8-square-mile basin drained by Carbonera Creek. Younger alluvium and older marine sediments.	1,100	200	Unknown	Unknown	Unknown

GROUND WATER RESOURCES
COASTAL
AREA—Continued

Development	Degree of knowledge	Problems
Intensive for irrigation use and limited to moderate for industrial and domestic use. Recharge is estimated at about 2,250 AFY. A potential for limited additional development.	Superficial for geology and hydrology. Limited for water quality. References: DWR 13, 167	None known.
Moderate for irrigation and limited for domestic use. Natural recharge is estimated at about 2,000 AFY. A potential for limited additional development.	Superficial for geology and hydrology. Limited for water quality. References: DWP 13, 167	Along coastal margin, TDS, chloride and sulfate high for domestic use. Locally, TDS and nitrate high for domestic use.
Intensive for irrigation and limited for industrial and domestic use. Recharge is estimated at about 12,000 AFY. A potential for limited additional development.	High for geology in coastal area, limited inland. Moderate for hydrology and water quality. References: DWR 13, 53, 65, 157, 167	Commonly nitrates high for domestic use in lower Arroyo Grande Valley. Along coastal margin TDS, chloride, and sulfate high for domestic use.
Intensive for irrigation, moderate for municipal and industrial use, and limited for domestic use. Extractions about 100,000 AFY. Safe yield 60,000 AFY. No potential for further development.	High for geology in coastal area, moderate inland. Moderate for hydrology and water quality. References: DWR 13, 53, 168; USGS 82, 133	Locally TDS high for domestic use. Overdraft.
Intensive for irrigation and limited for domestic, municipal and stock use. Safe yield 6600 AFY. A potential for limited to moderate additional development.	Moderate for geology central area and limited at ends. Moderate for hydrology. Limited for water quality. References: DWR 13; USGS 113, 115, 124	Locally unsuitable for domestic and irrigation uses.
Moderate for irrigation and limited for domestic use. A potential for limited additional development.	Moderate for geology, hydrology and water quality. References: DWR 170; USGS 60, 68, 90	Locally TDS high for domestic and irrigation use.
Intensive for irrigation, moderate for municipal and limited for domestic use. Extractions about 52,000 AF in 1960. Safe yield 40,000 AFY. A potential for limited additional development.	Moderate for geology, hydrology and water quality. References: DWR 165; USBR 10; USGS 40, 69, 122, 129	Locally TDS high for domestic and irrigation use.
Intensive for irrigation and limited for municipal and domestic use. A potential for limited additional development.	Moderate for geology, hydrology and water quality. References: USGS 39, 68, 123	Locally TDS manganese and iron high for domestic use.
Limited for municipal, irrigation, industrial, domestic, and stock use. A potential for limited additional development.	Moderate for geology and hydrology. Limited for water quality. References: DWR 55, USGS 91, 123	TDS high for domestic use. Boron and chloride high. Potential sea-water intrusion.
Intensive for irrigation and limited for municipal and domestic use. A potential for limited additional development.	Moderate for geology and hydrology. Limited for water quality. References: DWR 55; USGS 39, 68, 123	Possible sea-water intrusion.
Limited for irrigation, municipal and domestic use. 1967 extractions about 600 AF. A potential for limited to moderate additional development.	Limited for geology, hydrology, and water quality. References: DWR 13	Near Soda Lake and areas to the north and south generally unsuitable for domestic and irrigation uses.
Limited for domestic use. Potential for further development unknown.	Superficial for geology, hydrology, and water quality. References. DWR 2	Small well yields.
Moderate for irrigation and domestic use. 1969 pumpage did not lower water levels. A potential for limited additional development.	Moderate for geology. Limited for hydrology and water quality. References: DWR 130; USGS 1	None known.



GROUND WATER BASINS - SOUTH COASTAL HYDROLOGIC STUDY AREA

SOUTH COASTAL HYDROLOGIC STUDY AREA

Ground Water Basins

No.	Old No.	Name	County
4-1	....	Upper Ojai Valley	Ventura
4-2	....	Ojai Valley.......	Ventura
4-3	....	Ventura River Valley..	Ventura
4-4	....	Santa Clara River Valley .	Ventura
4-4.07	....	Santa Clara River Valley Eastern Basin	Los Angeles
4-5	....	Acton Valley..........	Los Angeles
4-6	....	Pleasant Valley.........	Ventura
4-7	....	Arroyo Santa Rosa Valley.	Ventura
4-8	....	Los Posas Valley......	Ventura
4-9	....	Simi Valley.......	Ventura
4-10	....	Conejo Valley.........	Ventura
4-11	....	Coastal Plain-Los Angeles Co.	Los Angeles
4-12	....	San Fernando Valley	Los Angeles
4-13	......	San Gabriel Valley......	Los Angeles
4-14	....	Upper Santa Ana Valley.	Los Angeles
4-15	....	Tierra Rejada Valley....	Ventura
4-16	....	Hidden Valley....	Ventura
4-17	....	Lockwood Valley..	Ventura
4-18	....	Hungry Valley.......	Los Angeles, Ventura
4-19	....	Thousand Oaks Area..	Ventura
4-20	....	Russell Valley.......	Los Angeles, Ventura
4-21	.....	Conejo-Tierra Rejada Volcanic Areas	Los Angeles, Ventura
4-22	....	Malibu Valley........	Los Angeles
8-1	....	Coastal Plain—Orange Co.	Orange
8-2	....	Upper Santa Ana Valley .	Riverside, San Bernardino
8-3	......	Cajalco Valley (Inundated by Lake Mathews)	Riverside
8-4		Elsinore Basin..........	Riverside
8-5		San Jacinto Basin......	Riverside
8-6		Hemet Lake Valley (Garner Valley)	Riverside
8-7		Big Meadows Valley....	San Bernardino
8-8		Seven Oaks Valley......	San Bernardino
8-9		Bear Valley	San Bernardino
9-1		San Juan Valley.......	Orange
9-2		San Mateo Valley......	San Diego
9-3		San Onofre Valley......	San Diego
9-4		Santa Margarita Valley...	San Diego
9-5		Temecula Valley......	Riverside
9-6		Coahuila Valley....	Riverside
9-7		San Luis Rey Valley ..	San Diego
9-8		Warner Valley.....	San Diego
9-9		Escondido Valley..	San Diego
9-10		San Pasqual Valley. ..	San Diego
9-11		Santa Maria Valley.	San Diego
9-12		San Dieguito Valley.	San Diego
9-13		Poway Valley....	San Diego
9-14		Mission Valley......	San Diego
9-15		San Diego River Valley.	San Diego
9-16		El Cajon Valley....	San Diego
9-17		Sweetwater Valley	San Diego
9-18		Otay Valley.......	San Diego
9-19		Tia Juana Basin......	San Diego
9-20		Jamul Valley....	San Diego
9-21		Las Pulgas Valley....	San Diego
9-22		Batiquitos Lagoon Valley.	San Diego
9-23		San Elijo Valley......	San Diego
9-24		Pamo Valley.....	San Diego
9-25	....	Ranchita Town Area.	San Diego
9-26	....	Pine Valley......	San Diego
9-27	....	Cottonwood Valley	San Diego
9-28	......	Campo Valley.....	San Diego
9-29	......	Potrero Valley....	San Diego
9-30	....	Tecate Valley....	San Diego

Summary

The South Coastal Hydrologic Study Area (HSA) comprises the coastal drainage basins of California north of the Tia Juana River basin to the Ventura River drainage basin in western Ventura County.

In this HSA, 62 ground water basins and areas of potential ground water storage have been identified. The inventory covers 42 ground water basins. These 42 basins, with a total area of about 3,200 square miles, have been identified as significant sources of ground water. The water-bearing deposits vary in thickness up to about 4,000 feet.

Total storage capacity of 35 basins at selected depth intervals is about 146.7 million acre-feet. The estimated usable storage capacity of 29 of the basins is about 10.4 million acre-feet. One limiting factor considered in estimating usable storage capacity of the coastal basins is sea-water intrusion. Sea-water intrusion occurs in one or more of these basins in each of the coastal counties and is a potential threat in all basins whose ground water levels are drawn down below sea level. Sea-water intrusion is being controlled artificially in Los Angeles and Orange counties only.

Ground water temperatures generally vary from about 55° to about 90°F. TDS content of the water varies considerably from basin to basin.

In most basins the ground water is suitable for all beneficial uses. In basins where Colorado River water is being used for recharge, the ground water has begun to take on the qualities of the recharge water and is inferior to the natural water in the HSA. Hardness is another common water quality problem in many basins.

Almost all of the basins are highly developed except in San Diego County, where the basins are not as extensive and, in some cases, contain water of inferior quality, not suitable for domestic use.

Ground water extractions in the HSA are estimated in excess of 1.7 million acre-feet.

Basin number	Basin name, county	Basin description: size, major stream, water bearing material	Well yields in gpm		Depth zone in feet	Storage capacity in acre-feet	Usable capacity in acre-feet
			Max.	Aver.			
4-1	Upper Ojai Valley, Ventura County	A 3-square-mile basin drained by Lion and Sisar Creeks. Younger alluvium.	200	50	Average ground surface elevation to base of fresh water	6,000	1,000
4-2	Ojai Valley, Ventura County	A 13-square-mile basin drained by San Antonio Creek. Younger alluvium.	600	150	Average ground surface elevation to base of fresh water	85,000	25,000
4-3	Ventura River Valley, Ventura County	A 10-square-mile coastal basin drained by the Ventura River. Younger alluvium.	1,000+	600	Average ground surface elevation to base of fresh water.	35,000	3,500
4-4	Santa Clara River Valley, Ventura and Los Angeles Counties. (Includes 4-4.07, Eastern Basin, Los Angeles County)	A 336-square-mile river valley and coastal plain drained by Santa Clara River and Revolon Slough. Younger and older alluvium.	3,000	800	Average ground surface elevation to base of fresh water	30,000,000	Unknown
4-5	Acton Valley, Los Angeles County	A 10-square-mile basin drained by the Santa Clara River. Younger alluvium.	1,000	140	10–60	40,000	16,000
4-6	Pleasant Valley, Ventura County	A 47-square-mile basin drained by Calleguas Creek. Younger and older alluvium, and older volcanics and sediments.	2,400	1,000	Average ground surface elevation to base of fresh water	1,886,000	Unknown
4-7	Arroyo Santa Rosa Valley, Ventura County	A 9-square-mile basin drained by Conejo Creek and Arroyo Santa Rosa. Younger and older alluvium, and older volcanics and sediments.	1,200	450	Average ground surface elevation to base of fresh water	94,000	3,100
4-8	Los Posas Valley, Ventura County	A 79-square-mile basin drained by Beardsley Wash and Arroyo Los Posas. Younger and older alluvium.	1,200	600	Average ground surface elevation to base of fresh water	4,250,000	950,000
4-9	Simi Valley, Ventura County	A 25-square-mile basin drained by Arroyo Simi. Younger alluvium.	1,000	250	Average ground surface elevation to base of fresh water	180,000	4,700

GROUND WATER RESOURCES
COASTAL
STUDY AREA

Development	Degree of knowledge	Problems
Moderate for irrigation and municipal use. Limited for domestic and industrial uses. Natural recharge estimated at about 400 AFY. A potential for limited additional development.	Limited for geology, hydrology, and water quality. References: DWR 9, 19, 37, 68; Misc. 16	Locally, TDS high for domestic use; marginal for irrigation use.
Intensive for irrigation use. Moderate for municipal use. Limited for industrial use. Natural recharge estimated at about 1,500 AFY. 1970 extractions 2,500 AF. A potential for limited development.	Limited for geology, hydrology, and water quality. References: DWR 9, 19, 37, 67, 68; USBR 11; Misc. 16	Locally, nitrate high and TDS marginal for domestic use. Overdraft. Adverse salt balance.
Moderate for municipal use. Limited for irrigation, industrial and domestic use. Natural recharge greater than 3,500 AFY. 1970 extractions 7,500 AF. A potential for limited additional development.	Limited for geology, hydrology, and water quality. References: DWR 9, 19, 49, 68; USBR 11; Misc. 16	Locally, TDS and sulfate high for domestic use and marginal for irrigation and marginal boron. In the lower River Valley, locally, sulfate, TDS, and chloride high for domestic use; TDS, chloride and percent sodium high for irrigation use.
Moderate to intensive for irrigation and municipal use. Limited for domestic and industrial use. Natural recharge is estimated at about 100,000 AFY. 1970 extractions about 175,000 AF. A potential for limited additional development.	Moderate to intensive for geology, hydrology, and water quality. References: DWR 9, 19, 28, 51, 54, 67, 68, 109, 138, 147, 160, 183; SWRCB 4; USBR 7; USGS 96, 111	Locally, magnesium, sulfate, chloride, nitrate and TDS high for domestic use; TDS chloride and boron high for irrigation use. Overdraft. Seawater intrusion. Failing septic tanks in unincorporated areas of Piru.
Intensive for municipal and agricultural use. Natural recharge is estimated at about 650 AFY. 1970 extractions about 1,000 AF. A potential for limited additional development.	Superficial for geology, hydrology, and water quality. References: DWR 147; USGS 13	None known.
Intensive for irrigation, moderate for municipal, and limited for industrial and domestic uses. Natural recharge estimated at about 11,000 AFY. 1970 extractions about 24,000 AF. A potential for limited additional development.	Moderate for geology, hydrology, and water quality. References: DWR 9, 19, 67, 68, 109; USBR 7	Locally, magnesium, sulfate, chloride, nitrate, and TDS high for domestic use, chloride and TDS high for irrigation use. Overdraft.
Intensive for irrigation, moderate for municipal, limited for industrial and domestic uses. Natural recharge estimated at about 3,000 AFY. 1970 extractions about 2,300 AF. A potential for limited additional development.	Moderate for geology, hydrology, and water quality. References: DWR 9, 19, 67, 68, 109; USBR 7	Locally, nitrate high for domestic use; water, derived from older volcanics and sediments.
Intensive for irrigation, moderate for municipal, limited for industrial and domestic use. Natural recharge estimated at about 10,800 AFY. 1970 extractions about 18,700 AF. A potential for limited additional development.	Moderate for geology, hydrology and water quality. References: DWR 9, 19, 67, 68, 109, 160	Locally, high chloride and TDS for domestic use; TDS, boron, and chloride high for irrigation use.
Limited for irrigation, municipal, industrial and domestic use. Natural recharge estimated at about 4,700 AFY. 1970 extractions about 3,500 AF. A potential for limited additional development.	Moderate for geology, hydrology, and water quality. References: DWR 9, 19, 67, 68	Locally, sulfate, and TDS high for domestic use, boron high for irrigation use. High ground water table. Failing septic tank and leach field systems.

Basin number	Basin name, county	Basin description: size, major stream, water bearing material	Well yields in gpm		Depth zone in feet	Storage capacity in acre-feet	Usable capacity in acre-feet
			Max.	Aver.			
4-10	Conejo Valley, Ventura County	A 4-square-mile basin drained by the South Branch Arroyo Conejo. Younger alluvium and older volcanics and sediments.	1,000	50	Average ground surface elevation to base of fresh water.	Unknown	2,600
4-11	Coastal Plain of Los Angeles, Los Angeles County	A 500-square-mile coastal plain drained mainly by the Los Angeles and San Gabriel Rivers. Younger alluvium.	2,000	600	1960 water levels to 2000 feet below ground surface.	31,730,000	2,363,000
4-12	San Fernando Valley, Los Angeles County	A 200-square-mile basin drained by the Los Angeles River. Younger and older alluvium.	3,240	1,220	1960 water levels to base of water-bearing unit.	3,400,000	3,200,000
4-13	San Gabriel Valley, Los Angeles County	A 200-square-mile basin drained by the Rio Hondo and San Gabriel Rivers. Younger alluvium.	4,850	1,000	Average ground surface elevation to base of fresh water.	10,438,000	Unknown
4-14	Upper Santa Ana Valley, Los Angeles County	A 30-square-mile basin drained by Live Oak and Thompson Washes. Younger alluvium.	750	100	1960 water levels to base of fresh water.	750,000	Unknown
8-1	Coastal Plain of Orange County, Orange County	A 360-square-mile coastal plain drained primarily by the Santa Ana River. Younger alluvium.	1,000	600	1960 water levels to base of fresh water	40,000,000	Unknown
8-2	Upper Santa Ana Valley, Riverside and San Bernardino Counties	A 620-square-mile basin drained primarily by the Santa Ana River. Younger and older alluvium.	4,500	800	1960 water levels to base of fresh water	16,000,000	2,000,000
8-4	Elsinore Basin, Riverside County	A 26-square-mile basin with drainage to Elsinore Lake. Younger alluvium.	4,400	200	Between 15 feet below ground surface and 1948–49 winter water levels.	27,000	Unknown
8-5	San Jacinto Basin, Riverside County	A 235-square-mile basin drained by the San Jacinto River. Younger and older alluvium.	1,000	100	Between 1960 water table and 2,000 ft. below ground surface.	6,100,000	1,300,000

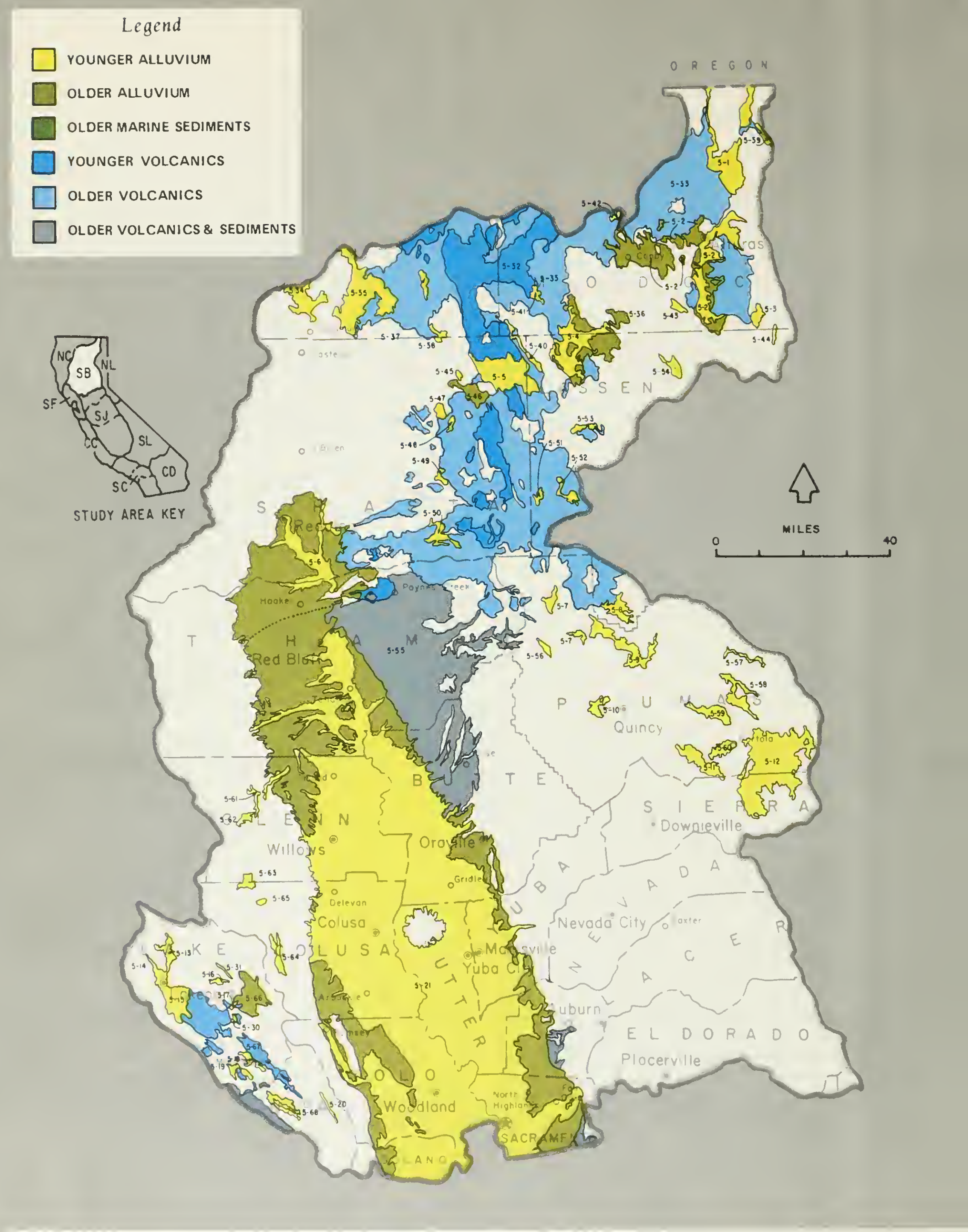
Development	Degree of knowledge	Problems
Limited for all uses. Natural recharge estimated at about 2,600 AFY. 1970 extractions about 300 AF. A potential for limited additional development.	Limited for geology, hydrology, and water quality. References: DWR 9, 19, 68	Locally, sulfate, chloride, and TDS high for domestic use.
Intensive for municipal, moderate for industrial, and limited for irrigation uses. 1973-74 extractions about 280,000 AFY. A potential for limited additional development.	Intensive for geology, hydrology, and water quality. References: DWR 5, 29, 44, 48, 50, 62, 99, 100, 101, 102, 114, SWRCB 5; USGS 102, 103; Misc. 8	Locally, chloride, sulfate, TDS, iron, and manganese high for domestic use; TDS and chloride high for irrigation use. Overdraft. Sea water intrusion controlled by injection barrier.
Intensive for municipal, domestic and industrial use. Safe yield about 57,000 AFY. 1973-74 extractions about 106,400 AF. A potential for limited additional development conjunctively with the State Water Project.	High to intensive for geology, hydrology and water quality. References: DWR 381; SWRCB 1, Misc. 18	Locally, poor quality water. Poor quality water is moving into the well fields from the southwest portion of the basin.
Moderate to intensive for municipal and industrial use. Limited for irrigation and domestic use. Recharge under 1960 cultural conditions 166,000 AF. 1974 extractions about 250,000 AF. A potential for limited additional development.	High to intensive for geology, hydrology, and water quality. References: DWR 26, 33, 103, 107, 146, 173	Locally, TDS marginal and nitrate high for domestic use. Overdraft.
Moderate to intensive for irrigation and municipal use. Limited for industrial and domestic use. A potential for limited additional development.	High for geology, hydrology, and water quality. References: DWR 104, 105, 175	Locally, nitrate and TDS high for domestic use.
Intensive for irrigation, municipal and industrial use. Moderate for domestic use. Recharge estimated at 221,000 AFY. 1956 extractions about 200,000 AF. A potential for limited additional development.	Intensive for geology, and hydrology. High for water quality. References: DWR 5, 52, 137, 190; USGS 20, 46, 85, 102, 104, 114	TDS marginal for domestic use. Sea water intrusion. Overdraft.
Moderate to intensive for irrigation, municipal and industrial uses. Limited for domestic use. Safe yield about 230,000 AFY. 1970 ground water extractions about 460,000 AF. A potential for limited additional development.	High to intensive for geology, hydrology, and water quality. References: DWR 104, 105, 106, 174, 175; USGS 29, 30, 33, 34, 43, 86, 108, 128; Misc. 13	Locally, nitrate and TDS high for domestic use. Overdraft.
Moderate for irrigation and municipal use. Limited for domestic use. Natural recharge estimated at about 4,000 AFY. A potential for limited additional development.	Limited for geology, hydrology, and water quality. References: DWR 6, 12, 17; USGS 119	Locally, fluoride and TDS high for domestic use; percent sodium high for irrigation use. Overdraft.
Moderate to intensive for irrigation use. Moderate for municipal and military uses. Limited for domestic and industrial use. Recharge estimated at about 26,000 AFY (includes Hemet Valley). 1970 extractions about 100,000 AF. A potential for limited additional development.	Moderate for geology, hydrology, and water quality. References: DWR 12, 24, 31	Locally, nitrate, chloride, and TDS high for domestic use; boron, chloride, TDS and percent sodium high for irrigation use.

Basin number	Basin name, county	Basin description: size, major stream, water bearing material	Well yields in gpm		Depth zone in feet	Storage capacity in acre-feet	Usable capacity in acre-feet
			Max.	Aver.			
8-6	Hemet Lake Valley, (Garner Valley) Riverside County	A 16-square-mile basin drained by the South Fork of the San Jacinto River. Younger and older alluvium.	820	270	Unknown	Included in Basin No. 8-5	Unknown
8-7	Big Meadows Valley, San Bernardino County	A 7-square-mile basin drained by the Santa Ana River. Younger alluvium.	Unknown	Unknown	10-60	10,000	3,500
8-8	Seven Oaks Valley, San Bernardino County	A 10-square-mile basin drained by the Santa Ana River. Younger alluvium.	Unknown	Unknown	10-60	14,000	4,700
8-9	Bear Valley, San Bernardino County	A 30-square-mile basin drained by Bear Creek. Younger alluvium.	1,000	500	10-60	42,000	14,000
9-1	San Juan Valley, Orange County	An 18-square-mile coastal basin drained by San Juan and Aliso Creeks. Younger alluvium.	1,600	500	Ground surface to base of fresh water-bearing aquifer.	90,000	9,000
9-2	San Mateo Valley, San Diego County	A 4-square-mile coastal basin drained by San Mateo Creek. Younger alluvium.	1,800	700	5-55	14,000	14,000
9-3	San Onofre Valley, San Diego County	A 2-square-mile coastal basin drained by San Onofre Creek. Younger alluvium.	150	50	5-55	6,500	6,500
9-4	Santa Margarita Valley, San Diego County	A 13-square-mile coastal basin drained by the Santa Margarita River. Younger alluvium.	2,000	1,250	5-100	61,600	24,000
9-5	Temecula Valley, Riverside County	A 150-square-mile basin drained by Murrieta Creek and the Santa Margarita River. Younger alluvium	1,750	750	1953 water level to 25 feet above base of younger alluvium	253,000	206,000
9-6	Coahuila Valley, Riverside County	A 25-square-mile basin drained by Coahuila Creek. Younger and older alluvium.	900	200	1953 water level to 25 feet above base of younger alluvium.	75,000	34,000
9-7	San Luis Rey Valley, San Diego County	A 40-square-mile coastal basin drained by the San Luis Rey River. Younger alluvium and residuum.	2,180	500	20-120	240,000	50,000
9-8	Warner Valley, San Diego County	A 40-square-mile basin drained by the San Luis River. Younger alluvium.	1,800	800	20-220	550,000	55,000

Development	Degree of knowledge	Problems
Limited for irrigation and domestic use. Natural recharge is included in Basin No. 8-5. A potential for limited additional development.	Superficial for geology and hydrology. Limited for water quality. References: DMG 6, USGS 126	Locally, TDS and nitrate high for domestic use.
Limited for domestic use. A potential for limited additional development.	Superficial for geology, hydrology, and water quality. References: DWR 18, DMG 7	None known.
Limited for domestic use. A potential for limited additional development.	Superficial for geology, hydrology, and water quality. References: DWR 18, DMG 7	None known.
Limited for domestic use. A potential for limited additional development.	Superficial for geology, hydrology, and water quality. References: DWR 18 DMG 7	None known.
Moderate for irrigation and municipal use and limited for domestic and industrial use. Natural recharge is estimated to be greater than 10,500 AFY. Extractions about 5,000 AFY. A potential for limited additional development.	High for geology and hydrology. Moderate for water quality. References: DWR 108, 113, 150; SWRCB 3	Lower portion sulfate, chloride, magnesium and TDS high for domestic use TDS, chloride, and boron high for irrigation use. Rising ground water and ponding.
Moderate for irrigation use and limited for municipal, industrial, and military use. A potential for limited additional development.	Superficial for geology, hydrology, and water quality. References: DWR 49, 113	None known.
Moderate for irrigation use and limited for domestic and military use. A potential for limited additional development.	Superficial for geology, hydrology, and water quality. References. DWR 49, 113	None known.
Intensive for military use, moderate for irrigation, and limited for municipal and industrial use. Natural recharge is estimated at about 6,000 AFY. 1972–73 extractions 9,500 AF. A potential for limited additional development.	Moderate for geology, hydrology, and water quality. References: DWR 23, 49, 113, 182; USGS 57, 87	Lower portion, magnesium, sulfate, chloride, nitrate, and TDS high for domestic use chloride, boron and TDS high for irrigation use. Potential for sea water intrusion. Connate waters.
Moderate for irrigation and limited for municipal, industrial and domestic uses. 1953 extractions about 12,000 AF. A potential for limited additional development.	Moderate for geology, hydrology, and water quality. References: DWR 23, 32, 93, 182	Locally, sulfate, chloride, magnesium, nitrate, and TDS high for domestic use; TDS high for irrigation use.
Moderate for irrigation use and limited for domestic use. 1953 extractions about 1,600 AF. A potential for limited additional development.	Limited for geology, hydrology, and water quality. References: DWR 23, 32, 95; USGS 57, 87	Locally, sulfate, and nitrate high for domestic use.
Moderate for irrigation and municipal use and limited for industrial and domestic use. A potential for limited to moderate additional development.	Moderate to intensive for geology, hydrology, and water quality. References: DWR 21, 48, 91, 113, 159; USGS 57, 87, 88	Generally southwest portion magnesium, sulfate, chloride, nitrate, iron, and TDS high for domestic use; chloride and TDS high for irrigation use. Sea water intrusion and connate water intrusion.
Limited for irrigation, municipal, domestic, industrial, and stock watering uses. A potential for limited to moderate additional development.	Limited for geology, hydrology, and water quality. References: DWR 91, 113; USGS 57, 87	Locally, fluoride high for domestic use; percent sodium high for irrigation use.

Basin number	Basin name, county	Basin description: size, major stream, water bearing material	Well yields in gpm		Depth zone in feet	Storage capacity in acre-feet	Usable capacity in acre-feet
			Max.	Aver.			
9-9	Escondido Valley, San Diego County	A 20-square-mile basin drained by Escondido Creek. Younger alluvium and residuum.	190	50	20–70	24,000	12,000
9-10	San Pasqual Valley, San Diego County	A 12-square-mile basin drained by Santa Ysabel Creek. Younger alluvium and residuum.	1,700	600	20–120	73,000	37,000
9-11	Santa Maria Valley, San Diego County	A 24-square-mile basin drained by Santa Maria Creek. Younger alluvium and residuum.	250	50	20–70	77,000	50,000
9-12	San Dieguito Valley, San Diego County	A 6-square-mile coastal basin drained by the San Dieguito River. Younger alluvium.	600	250	20–120	63,000	8,000
9-13	Poway Valley, San Diego County	A 4-square-mile basin drained by Los Penasquitos Creek. Younger alluvium and residuum.	200	100	Unknown	Unknown	Unknown
9-14	Mission Valley, San Diego County	A 11-square-mile coastal basin drained by the San Diego River. Younger alluvium.	1,000	300	0–100	42,000	10,500
9-15	San Diego River Valley, San Diego County	A 15-square-mile basin drained by the San Diego River. Younger alluvium and residuum.	750	250	0–195	97,000	24,200
9-16	El Cajon Valley, San Diego County	A 8-square-mile basin drained by Forrester Creek. Younger alluvium and residuum.	300	50	Unknown	Unknown	Unknown
9-17	Sweetwater Valley, San Diego County	A 3-square-mile coastal basin drained by the Sweetwater River. Younger alluvium.	600	Unknown	Unknown	Unknown	Unknown
9-18	Otay Valley, San Diego County	A 4-square-mile coastal basin drained by the Otay River. Younger alluvium.	400	160	Unknown	Unknown	Unknown
9-19	Tia Juana Basin, San Diego County	A 8-square-mile coastal basin drained by the Tia Juana River. Younger alluvium.	350	300	Unknown	Unknown	Unknown
9-20	Jamul Valley, San Diego County	A 5-square-mile basin drained by the Sweetwater River. Younger alluvium and residuum.	240	Unknown	Unknown	Unknown	Unknown

Development	Degree of knowledge	Problems
Moderate for irrigation and limited for industrial, domestic, and stock watering uses. Extractions about 6,000 AF in 1968. A potential for limited additional development.	Superficial for geology and limited for hydrology and water quality. References: DWR 59, 113, 166	Commonly marginal to unsuitable for domestic use, nitrate, TDS, chloride high for irrigation use.
Moderate for industrial and limited for domestic and stock watering uses. Natural recharge estimated at about 5,000 AFY. A potential for limited additional development.	Moderate for geology, hydrology, and water quality. References: DWR 22, 59; SWRCB 3; USGS 37	Locally, nitrate and TDS high for domestic use; chloride high for irrigation use. High ground water table and ponding.
Limited for irrigation, industrial, domestic, and stock watering uses. Natural recharge is estimated to be greater than 2,000 AFY. A potential for limited to moderate additional development.	Moderate for geology, hydrology, and water quality. References: DWR 22, 59, 186	Locally, sulfate, nitrate and TDS high for domestic use; chloride high for irrigation use.
Moderate for irrigation and limited for industrial and domestic uses. A potential for limited additional development.	Moderate for geology, hydrology, and water quality. References: DWR 22, 49, 59, 113, 186; USGS 37	Commonly unsuitable for domestic use, high sulfate and TDS. Commonly unsuitable for irrigation use, high TDS, chloride and boron potential. Potential sea-water and connate intrusion. High ground water table and ponding.
Moderate for irrigation and limited for domestic and stock uses. A potential for limited additional development.	Superficial for geology, hydrology, and water quality. References: DWR 113; USGS 37	Commonly marginal to unsuitable for domestic use. Locally, TDS, boron, and chloride high for irrigation use.
Moderate for irrigation use. Limited for municipal, industrial, and domestic use. A potential for limited additional development.	Moderate for geology, hydrology, and water quality. References: DWR 21, 49, 113, 141; SWRCB 3; USGS 37	Upper portion of valley, magnesium, sulfate, chloride, and TDS high for domestic use; TDS and chloride high for irrigation use. High ground water table and ponding. Suspected sea-water intrusion.
Moderate for irrigation use and limited for domestic, municipal, industrial and stock watering use. A potential for limited to moderate additional development.	Moderate for geology, hydrology, and water quality. References: DWR 21, 113, 141; USGS 37	Lower portion of valley, magnesium, sulfate, chloride, nitrate, manganese, iron and TDS high for domestic use; chloride high for irrigation use.
Moderate for irrigation use and limited for industrial and domestic use. A potential for limited additional development.	Moderate for geology, hydrology, and water quality. References: DWR 41, 113; USGS 37	Largely unsuitable for domestic use, high nitrate. Chloride high for irrigation use.
Moderate for irrigation use and limited for industrial and domestic use. Natural recharge is estimated at about 1,100 AFY. A potential for limited additional development.	Superficial for geology and hydrology. Limited for water quality. References: DWR 49, 113	Unsuitable for domestic use, high TDS. Unsuitable for irrigation use, high chloride and TDS. Connate intrusion.
Limited for municipal, irrigation, domestic and industrial uses. A potential for limited additional development.	Superficial for geology and hydrology. Limited for water quality. References: DWR 49, 113, 149	Lower portion unsuitable for domestic use, high TDS. Unsuitable for irrigation use, high chloride and TDS.
Extensive for irrigation and limited for industrial, domestic and military uses. Natural recharge is estimated at about 8,000 AFY. 1952-53 extractions about 18,000 AF. A potential for limited additional development.	High for geology. Moderate for hydrology and water quality. References: DWR 25, 35, 36, 49, 113	Unsuitable for domestic use, high sulfate and TDS. Unsuitable for irrigation use, high chloride and TDS.
Moderate for irrigation use. Limited for industrial, domestic and stock watering use. A potential for limited additional development.	Superficial for geology and hydrology. Limited for water quality. References: DWR 113; DMG 9	Locally marginal to unsuitable for domestic use, high nitrate and TDS. Generally marginal to inferior for irrigation use, high chloride.



GROUND WATER BASINS - SACRAMENTO BASIN HYDROLOGIC STUDY AREA

SACRAMENTO BASIN HYDROLOGIC STUDY AREA

Ground Water Basins

No.	Old No.	Name	County	No.	Old No.	Name	County
5-1	....	Goose Lake Valley......	Modoc	5-34	....	Mount Shasta Area......	Siskiyou
5-2	....	Alturas Basin...........	Modoc	5-35	....	McCloud Area...........	Siskiyou
5-2.01	....	South Fork Pit River and Alturas Area	Modoc	5-36	....	Round Valley...........	Modoc
				5-37	....	Toad Well Area.........	Siskiyou
5-2.02	....	Warm Springs Valley..	Modoc	5-38	....	Pondosa Town Area.....	Shasta, Siskiyou
5-3	....	Jess Valley............	Modoc				
5-4	....	Big Valley.............	Lassen, Modoc	5-39	....	Fandango Valley........	Modoc
				5-40	....	Hot Spring Valley.......	Lassen, Modoc, Shasta
5-5	....	Fall River Valley........	Lassen, Shasta				
5-6	....	Redding Basin..........	Shasta, Tehama	5-41	....	Egg Lake Valley........	Modoc
				5-42	....	Bucher Swamp Valley....	Modoc
5-7	....	Lake Almanor Valley....	Plumas	5-43	....	Rocky Prairie Valley.....	Modoc
5-8	....	Mountain Meadows Valley	Lassen	5-44	....	Long Valley............	Lassen, Modoc
5-9	....	Indian Valley...........	Plumas	5-45	....	Cayton Valley..........	Shasta
5-10	....	American Valley........	Plumas	5-46	....	Lake Britton Area.......	Shasta
5-11	....	Mohawk Valley........	Plumas	5-47	....	Goose Valley..........	Shasta
5-12	....	Sierra Valley	Plumas, Sierra	5-48	....	Burney Creek Valley....	Shasta
				5-49	....	Dry Burney Creek Valley.	Shasta
5-13	....	Upper Lake Valley......	Lake	5-50	....	North Fork Battle Creek Valley	Shasta
5-14	....	Scott Valley............	Lake				
5-15	....	Kelseyville Valley (Big Valley)	Lake	5-51	....	Butte Creek Valley......	Lassen
				5-52	....	Gray Valley............	Lassen
5-16	....	High Valley...........	Lake	5-53	....	Dixie Valley............	Lassen
5-17	....	Burns Valley...........	Lake	5-54	....	Ash Valley............	Lassen
5-18	....	Coyote Valley..........	Lake	5-55	....	Sacramento Valley Eastside Tuscan Formation Highlands	Butte, Plumas, Tehama
5-19	....	Collayomi Valley.......	Lake				
5-20	....	Berryessa Valley........	Napa				
5-21	....	Sacramento Valley.......	Butte, Colusa, Glenn, Placer, Sacramento, Solano, Sutter, Tehama, Yolo, Yuba	5-56	....	Yellow Creek Valley....	Plumas
				5-57	....	Last Chance Creek Valley	Plumas
				5-58	....	Clover Valley..........	Plumas
				5-59	....	Grizzly Valley..........	Plumas
				5-60	....	Humbug Valley.........	Plumas
				5-61	....	Chrome Town Area.....	Glenn
				5-62	....	Elk Creek Area.........	Glenn
				5-63	....	Stonyford Town Area....	Colusa, Glenn
				5-64	....	Bear Valley............	Colusa
				5-65	....	Little Indian Valley	Lake
5-30	....	Lower Lake Valley......	Lake	5-66	....	Clear Lake Cache Formation Highlands	Lake
5-31	....	Long Valley............	Lake				
5-32	....	Modoc Plateau Recent Volcanic Areas	Lassen, Modoc, Shasta, Siskiyou	5-67	....	Clear Lake Pleistocene Volcanics	Lake
				5-68	....	Pope Valley............	Lake
5-33	....	Modoc Plateau Pleistocene Volcanic Areas	Lassen, Modoc, Plumas, Shasta, Siskiyou, Tehama				

Summary

The Sacramento Basin Hydrologic Study Area (HSA) generally includes the northern third of the Great Central Valley and the upper Sacramento River drainage area. In this HSA, 61 ground water basins, subareas, and areas of potential ground water storage have been identified. The inventory covers 24 ground water basins and sub-basins. These 24 basins, with a total area of about 6,400 square miles, have been identified as significant sources of ground water. Sacramento Valley alone occupies 5,000 square miles. The southern portion of the Sacramento Valley ground water basin, Basin No. 5-21, is in the San Joaquin Basin HSA, and Sacramento Valley is only listed and described in the Sacramento Basin HSA.

Water bearing deposits range in thickness up to about 3,000 feet, and several basins contain flowing wells.

The estimated storage capacity of 22 basins is about 139.3 million acre-feet. Usable storage capacity of 8 basins is estimated to be about 22.1 million acre-feet, 22 million of which are in the Sacramento Valley. The principal factors limiting development are the low permeability of the aquifer material, water quality, and economic considerations such as the costs of well drilling and pumping energy.

Ground water temperature ranges from about 55° to

INVENTORY OF SACRAMENTO HYDROLOGIC

Basin number	Basin name, county	Basin description: size, major stream, water bearing material	Well yields in gpm		Depth zone in feet	Storage capacity in acre-feet	Usable capacity in acre-feet
			Max.	Aver.			
5-1	Goose Lake Valley, Modoc County	A 75-square-mile basin drained by the North Fork Pit River. Younger alluvium and older volcanics.	2,500	1,500	0–500	1,000,000	Unknown
5-2	Alturas Basin						
5-2.01	Alturas Basin—South Fork Pit River and Alturas area	A 140-square-mile basin drained by the South Fork Pit River. Younger and older alluvium and older volcanics.	1,000	400	0–800	6,700,000	Unknown
5-2.02	Alturas Basin—Warm Springs Valley, Modoc County	A 100-square-mile basin drained by the Pit River. Older alluvium and older volcanics.	1,000	400	0–800	1,600,000	Unknown
5-3	Jess Valley, Modoc County	A 9-square-mile basin drained by the South Fork Pit River. Younger alluvium.	Unknown	Unknown	Unknown	Unknown	Unknown
5-4	Big Valley, Lassen and Modoc Counties.	A 160-square-mile basin drained by the Pit River. Younger and older alluvium, and older volcanics.	900	300	0–1000	3,700,000	Unknown
5-5	Fall River Valley, Lassen and Shasta Counties	A 120-square-mile basin drained by the Pit River. Younger alluvium and younger and older volcanics.	2,500	450	0–400	1,000,000	Unknown
5-6	Redding Basin, Shasta and Tehama Counties	A 510-square-mile basin drained by the Sacramento River. Younger and older alluvium.	2,150	640	0–300	3,500,000	Unknown
5-7	Lake Almanor Valley, Plumas County	A 7-square-mile basin drained by the Feather River. Younger alluvium.	300	100	10–210	45,000	Unknown

about 75°F. TDS content varies from less than 55 milligrams per liter (mg/1) to as high as 2,790 mg/1. The predominant water type is calcium bicarbonate, but sodium and magnesium bicarbonate water are also found in certain areas.

Properly constructed wells in some areas can yield over 3,000 gallons per minute. Ground water pumping has caused land subsidence in the Sacramento Valley in an area between Zamora and Davis of about 0.2 to 0.9 feet from 1935 to 1964, and as much as 2 feet in two areas east of Zamora and west of Arbuckle. Total ground water pumpage in the HSA during 1970 is estimated at 2.0 million acre-feet.

Saline water at shallow depths has been encountered in a number of locations in the Sacramento Valley, principally in the Sutter Basin and the Sacramento Delta. High boron concentrations are found in certain locations in the following valleys: Goose Lake Valley, Alturas Basin, Sierra Valley, Upper Lake Valley, Kelseyville Valley, High Valley, Coyote Valley, and Lower Lake Areas.

The Sacramento Basin is an area of abundant and inexpensive surface water supplies. This is the main reason why ground water levels for the most part are at or near the historical high. Essentially, the basin is filled to its maximum storage capacity, and the potential for further development of ground water is very high.

GROUND WATER RESOURCES
BASIN
STUDY AREA

Development	Degree of knowledge	Problems
Limited for domestic, stock and irrigation use. Estimated 1974 pumpage 4,000 AF. Estimated safe yield 10,000 AFY. A potential for moderate additional development.	Limited for geology, hydrology and water quality. References: DWR 96, 97, 187	Northeastern portion has zones of high concentrations of fluoride, boron, and percent sodium. Thermal water at depth.
Moderate for domestic, irrigation, municipal, and stock use. For the entire Alturas Basin, estimated 1974 pumpage 9,000 AF: estimated safe yield 17,000 AFY. A potential for moderate additional development.	Limited for geology, hydrology and water quality. References: DWR 96, 97, 187	Localized zones of high nitrate, iron, boron, and percent sodium. One well produced water having 310 mg/l nitrates.
Moderate for domestic, irrigation, municipal and stock use. A potential for moderate additional development	Limited for geology, hydrology and water quality. References: DWR 96, 97	High percent sodium.
Limited for domestic and stock use. Additional potential unknown.	Superficial for geology, hydrology, and water quality. References: DWR 45, 185	None known.
Moderate for domestic, industrial, and stock use. Estimated 1974 pumpage 5,000 AF and estimated 1970 safe yield 10,000 AFY. Additional development for irrigation supply may be restricted due to tight sediments or low yielding sediments. A potential for limited additional development.	Limited for geology, hydrology and water quality. References: DWR 96, 97, 187; USBR 5	Poor quality thermal waters from hot springs—unsuitable for beneficial uses. High iron and manganese concentrations areawide. High nitrate concentrations locally. High sodium sulfate concentration in water in South Central part of basin.
Limited for irrigation and domestic use. 1970 pumpage 13,000 AF. Safe yield 39,000 AFY. Supplemental supply for irrigation appears promising. A potential for moderate additional development.	Limited for geology, hydrology, and water quality. References: DWR 66, 96, 97, 187	High iron, nitrate and excessive sodium locally.
Moderate for domestic, irrigation, municipal, stock and industrial use. Estimated 1970 pumpage 40,000 AF. Safe yield is greater than 46,000 AFY. Essentially, the ground water basin is full. A potential for high additional development except in northern part of basin.	Moderate for geology in central area, limited in outer area. Limited for hydrology, and water quality. References: DWR 16, 66, 139, 187	Saline water containing sodium and boron at shallow depth along the north half of basin.
Limited for domestic and irrigation use. A potential for limited additional development.	Superficial for geology, hydrology, and water quality. References: DWR 45.	None known.

Basin number	Basin name, county	Basin description: size, major stream, water bearing material	Well yields in gpm		Depth zone in feet	Storage capacity in acre-feet	Usable capacity in acre-feet
			Max.	Aver.			
5-8	Mountain Meadows Valley, Lassen County	A 10-square-mile basin drained by the Feather River. Younger alluvium and older volcanics.	Unknown	Unknown	Unknown	Unknown	Unknown
5-9	Indian Valley, Plumas County	A 20-square-mile basin drained by the Feather River. Younger alluvium.	500	150	10–210	100,000	Unknown
5-10	American Valley, Plumas County	A 7-square-mile basin drained by the Feather River. Younger alluvium.	1,000	250	10–210	50,000	Unknown
5-11	Mohawk Valley, Plumas County	A 8-square-mile basin drained by the North Fork of the Feather River. Younger alluvium.	Unknown	170	0–200	90,000	Unknown
5-12	Sierra Valley, Plumas and Sierra Counties.	A 140-square-mile basin drained by the North Fork of the Feather River. Younger alluvium.	1,800	300	0–1000	7,500,000	Unknown
5-13	Upper Lake Valley, Lake County	A 15-square-mile basin drained by Cold Creek. Younger alluvium.	900	300	10–100	10,900	5,000
5-14	Scott Valley, Lake County	A 4-square-mile basin drained by Scott Creek. Younger alluvium.	700	500	10–100	5,900	4,500
5-15	Kelseyville Valley, (Big Valley) Lake County	A 30-square-mile basin drained by Adobe Creek. Younger alluvium and older volcanics.	1,350	450	10–100	115,600	60,000
5-16	High Valley, Lake County	A 3-square-mile basin drained by the North Fork of Cache Creek. Younger alluvium.	1,000	100	10–100	9,000	900
5-17	Burns Valley, Lake County	A 2-square-mile basin draining into Clear Lake. Younger alluvium.	300	200	10–60	4,000	1,400
5-18	Coyote Valley, Lake County	A 6-square-mile basin drained by Putah Creek. Younger alluvium.	1,200	500	10–100	27,000	7,000
5-19	Collayomi Valley, Lake County	A 7-square-mile basin drained by Putah Creek. Younger alluvium.	1,200	500	10–100	29,000	7,000
5-21	Sacramento Valley, Butte, Colusa, Glenn, Placer, Sacramento, Solano, Sutter, Tehama, Yolo and Yuba Counties	A 5,000-square-mile basin drained by the Sacramento River. Younger and older alluvium and older volcanics and sediments.	4,000	800	20–600	113,650,000	22,000,000

Development	Degree of knowledge	Problems
Limited for domestic and stock use. A potential for limited additional development.	Superficial for geology, hydrology, and water quality. References: DWR 45	None known.
Limited for domestic, irrigation and stock use. A potential for limited additional development.	Superficial for geology, hydrology, and water quality. References: DWR 45	None known.
Limited for irrigation, domestic, and stock use. A potential for limited additional development.	Superficial for geology, hydrology, and water quality. References: DWR 45	None known.
Limited for irrigation, domestic, and stock use. Potential for developing additional irrigation water is restricted due to low permeability material underlying the valley floor. A potential for limited additional development.	Superficial for geology, hydrology, and water quality. References: DWR 96, 97	In local areas ground water is unsuitable for beneficial uses.
Limited for irrigation, domestic, and stock use. Ground water pumpage below safe yield. A potential for moderate to high additional development.	Limited for geology, hydrology, and water quality. References: DWR 96, 97, 184	Warm to hot ground waters high in fluoride and boron occur in the central portion of valley.
Moderate for irrigation, domestic, and stock use. Estimated 1966 pumpage 3,500 AF. Estimated safe yield 4,400 AFY. A potential for limited additional development.	Moderate for geology. Limited for hydrology and water quality. References: DWR 11, 45; USBR 12	High boron west and southern portions of the valley.
Moderate for irrigation, domestic, and stock use. Estimated safe yield 2,300 AFY. A potential for limited additional development.	Moderate for geology. Limited for hydrology and water quality. References: DWR 11, 45; USBR 12	None known.
Intensive for irrigation, domestic, and industrial use. Estimated 1966 pumpage 14,500 AF. Estimated safe yield 15,000 AFY. A potential for limited additional development.	Moderate for geology. Limited for hydrology and water quality. References: DWR 11, 45; USBR 12	High boron eastern, southern, and northern perimeters of the valley.
Moderate for domestic, irrigation, and stock use. Estimated 1966 pumpage 400 AF. Estimated safe yield 300 AFY. A potential for limited additional development.	Limited for geology, hydrology, and water quality. References: DWR 45; USBR 12; USGS 125	Local problems with high iron and boron content.
Limited for domestic, irrigation, and stock use. Estimated safe yield 600 AFY. A potential for limited additional development.	Limited for geology, hydrology, and water quality. References: DWR 45, USBR 12; USGS 125	Minor boron problems. Localized nitrate problems.
Moderate for domestic, irrigation, and stock use. Estimated 1966 pumpage 2,330 AF. Estimated safe yield 5,000 AFY. A potential for moderate additional development.	Moderate for geology. Limited for hydrology and water quality. References: DWR 98, USBR 6, 12; USGS 125	High boron.
Moderate for domestic, irrigation and stock use. A potential for moderate additional development.	Limited for geology, hydrology and water quality. References: DWR 98; USBR 12, USGS 125	None known.
Moderate to intensive for irrigation, domestic, stock and industrial use. Estimated 1970 pumpage 1,850,000 AF. A potential for high additional development in many locations in this basin, mainly near the Sacramento River and northern half of the basin.	Limited in geology, hydrology, and water quality except for several isolated areas of moderate, high and intensive. References. DWR 1, 3, 7, 15, 122, 124, 126, 193, 194, USBR 6; USGS 9, 11, 75, 94, 116; Misc. 15	Land subsidence as much as 2 feet, east of Zamora and west of Arbuckle, possibly caused by overdraft. Saline water at shallow depth south and west of Sutter Buttes. Moderately high boron in the Arbuckle and Woodland areas. Shallow poor quality water in Sacramento Delta area.

Basin number	Basin name, county	Basin description: size, major stream, water bearing material	Well yields in gpm		Depth zone in feet	Storage capacity in acre-feet	Usable capacity in acre-feet
			Max.	Aver.			
5-30	Lower Lake Valley, Lake County	A 5-square-mile basin drained by Seigler Creek. Younger alluvium.	300	Unknown	0–75	4,000	Unknown
5-36	Round Valley, Modoc County	A 15-square-mile basin drained by the Pit River. Younger and older alluvium.	400	150	0–200	120,000	Unknown
5-60	Humbug Valley, Plumas County	A 14-square-mile basin drained by the North Fork Feather River. Younger alluvium.	Unknown	Unknown	0–100	76,000	Unknown

Development	Degree of knowledge	Problems
Limited for domestic, and minor irrigation use. Estimated 1966 pumpage 270 AF. Estimated safe yield 800 AFY. A potential for limited to moderate additional development.	Limited for geology, hydrology, and water quality. References: USBR 12; USGS 125	High boron. Some waters unsatisfactory for domestic use.
Limited for domestic, irrigation, and stock use. Additional development for irrigation supply may be restricted due to low yielding sediments. A potential for limited additional development.	Limited for geology, hydrology, and water quality. References: DWR 96, 97	Low yielding sediments.
Limited for irrigation, domestic, and stock use. Additional development for irrigation water is restricted due to low permeability material underlying the valley floor. A potential for limited additional development.	Superficial for geology, hydrology, and water quality. References: DWR 96, 97	None known.

GROUND WATER BASINS - SAN JOAQUIN BASIN HYDROLOGIC STUDY AREA

SAN JOAQUIN BASIN HYDROLOGIC STUDY AREA

Ground Water Basins

No.	Old No.	Name	County
5-21		Sacramento Valley	Sacramento, Solano, Yolo
5-22		San Joaquin Valley	Alameda, Contra Costa, Fresno, Kern, Kings, Madera, Merced, Sacramento, San Joaquin, Stanislaus, Tulare
5-23		Panoche Valley	San Benito
5-24		Squaw Valley	Fresno
5-25		Kern River Valley	Kern
5-26		Walker Basin Creek Valley	Kern
5-27		Cummings Valley	Kern
5-28		Tehachapi Valley West	Kern
5-29		Castaic Lake Valley	Kern
5-69		Yosemite Valley	Mariposa
5-70		Los Banos Creek Valley	Merced
5-71		Vallecitos Creek Valley	San Benito
5-72		Cedar Grove Area	Fresno
5-73		Three Rivers Area	Tulare
5-74		Springville Area	Tulare
5-75		Templeton Mountain Area	Tulare
5-76		Manache Meadows Area	Tulare
5-77		Sacator Canyon Valley	Tulare
5-78		Rockhouse Meadow Valley	Tulare
5-79		Inns Valley	Kern, Tulare
5-80		Brite Valley	Kern
5-81		Bear Valley	Kern
5-82		Cuddy Canyon Valley	Kern
5-83		Cuddy Ranch Area	Kern, Ventura
5-84		Cuddy Valley	Kern
5-85		Mill Potrera Area	Kern

Summary

The San Joaquin Basin Hydrologic Study Area (HSA) includes roughly the southern two-thirds of the Great Central Valley of California. The HSA is bordered on the north by the Sacramento-San Joaquin Delta, on the east by the Sierra Nevada, on the south by the Tehachapi Mountains, and on the west by the Coast Ranges. The San Joaquin River drains a large part of the HSA, but the southern part of the HSA is an interior drainage area, tributary to evaporation sumps, chiefly Tulare and Buena Vista lakebeds. The northern part of the San Joaquin Basin HSA includes the southern portion of the Sacramento Valley ground water basin, Basin No. 5-21. Sacramento Valley Basin No. 5-21 is listed and described only in Sacramento Basin HSA.

In the HSA, 26 ground water basins and areas of potential ground water storage have been identified. The inventory covers nine ground water basins. These nine basins have been identified as significant sources of ground water. The total area of these nine basins is about 13,700 square miles, of which the San Joaquin Valley alone occupies 13,500 square miles, the largest ground water basin in the State.

The maximum thickness of fresh water-bearing deposits (4,400 feet) occurs at the southern end of the San Joaquin Valley just north of Wheeler Ridge. Estimated storage capacity between depths of 0 and 1,000 feet is over 570 million acre-feet. The estimated usable storage capacity exceeds 80 million acre-feet; the principal factors limiting development are water quality and the high cost of pumping. Estimated storage capacity in three small basins is about 475,000 acre-feet.

Ground water temperatures range from about 45° to about 105° F. TDS content of the water varies from 64 to more than 10,000 milligrams per liter. The predominant water type varies from aquifer to aquifer and the source of recharge. The character of the water on the east side of the valley is predominantly sodium-calcium bicarbonate; water on the west side principally contains sodium sulfate. Properly constructed wells in some areas yield over 3,000 gallons per minute.

Subsidence in the San Joaquin Valley due to ground water extraction began in the mid-1920s. In 1942, 3 million acre-feet were pumped for irrigation, but by 1970, pumping for irrigation exceeded 10 million acre-feet. As a result, water levels in the western and southern portions of the valley declined at an increased rate during the 1950s and 1960s. By 1970, 5,200 square miles of valley land had been affected, and maximum subsidence exceeded 28 feet in an area west of Mendota.

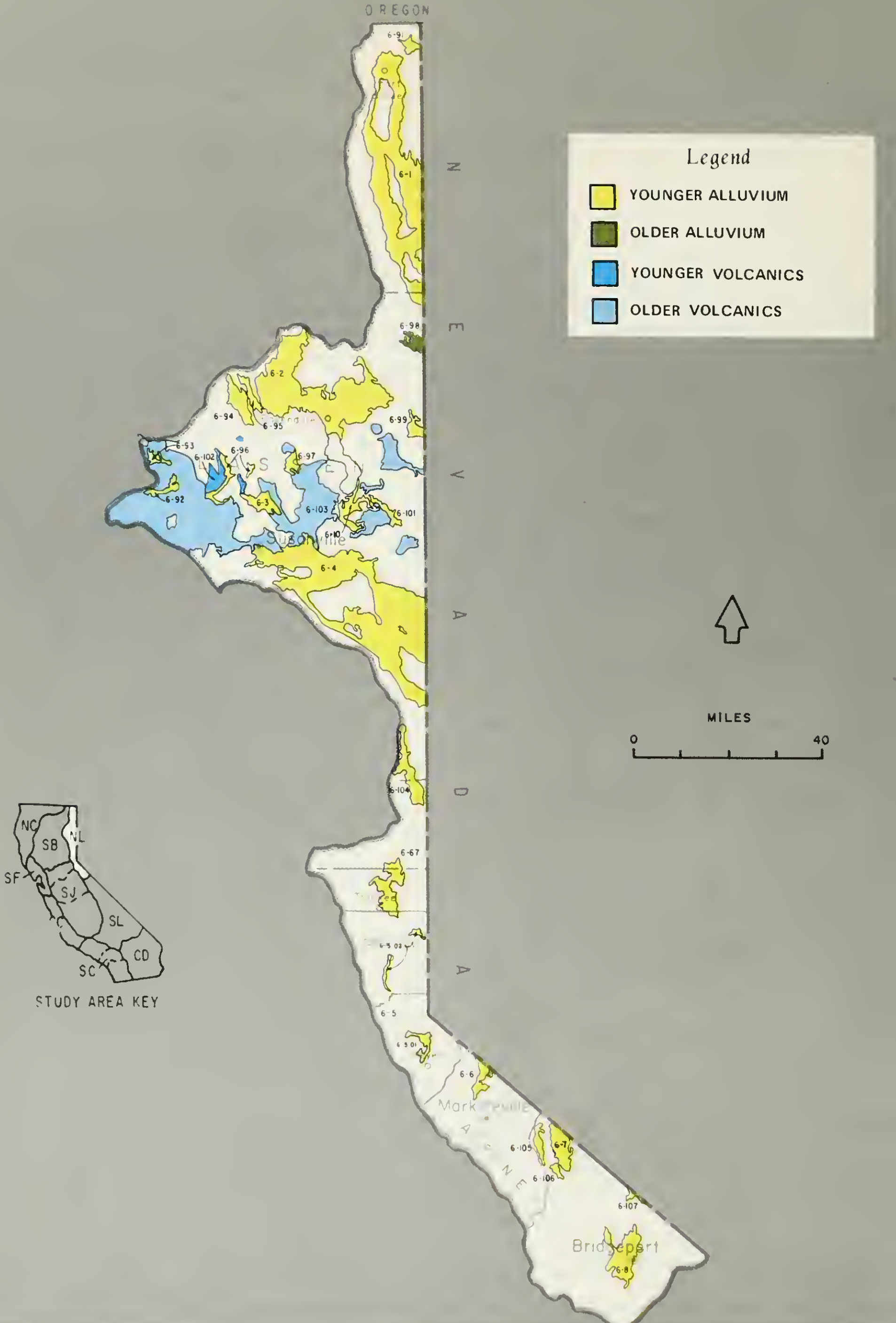
Much of the Los Banos-Kettleman City subsidence area is now served by the San Luis Unit of the Central Valley Project. Since 1968, as more state and federal water has been used for irrigation, water levels have been recovering. In one instance, the rise in piezometric level exceeded 200 feet, and in about three-fourths of the area the rise has been over 100 feet. In the future, when the full contractual Project deliveries are made, subsidence in this area is expected to cease. Since 1971, State Water deliveries to some parts of the Wheeler Ridge-Maricopa Water Storage District in Kern County have resulted in a ground water level recovery of as much as 75 feet.

Artificial recharge is the intentional replenishment of ground water. Extensive use of natural stream channels and man-made basins allows large volumes of surface water to percolate into the ground water basin. In 1973, for this HSA, 1.6 million acre-feet were artificially recharged or stored in the San Joaquin Valley ground water basin for future use.

Basin number	Basin name, county	Basin description: size, major stream, water bearing material	Well yields in gpm		Depth zone in feet	Storage capacity in acre-feet	Usable capacity in acre-feet
			Max.	Aver.			
5-22	San Joaquin Valley, Alameda, Contra Costa, Fresno, Kern, Kings, Madera, Merced, Sacramento, San Joaquin, Stanislaus, and Tulare Counties	A 13,500-square-mile basin drained by the San Joaquin River. Younger and older alluvium.	3,200	1,100	0–1000	570,000,000	80,000,000
5-23	Panoche Valley, San Benito County	A 50-square-mile basin drained by Panoche Creek. Younger and older alluvium.	Unknown	Unknown	Unknown	Unknown	Unknown
5-24	Squaw Valley, Fresno County	A 8-square-mile basin drained by Wahtoke Creek. Younger alluvium.	Unknown	Unknown	Unknown	Unknown	Unknown
5-25	Kern River Valley, Kern County	A 70-square-mile basin drained by the Kern River. Younger alluvium.	Unknown	Unknown	Unknown	Unknown	Unknown
5-26	Walker Basin Creek Valley, Kern County	A 16-square-mile basin drained by Walker Basin Creek. Younger alluvium.	Unknown	Unknown	Unknown	Unknown	Unknown
5-27	Cummings Valley, Kern County	A 13-square-mile basin drained by Cummings Creek. Younger alluvium.	Unknown	Unknown	0–450	110,000	Unknown
5-28	Tehachapi Valley — West, Kern County	A 37-square-mile basin with internal drainage. Younger and older alluvium.	Unknown	Unknown	0–600	350,000	Unknown
5-29	Castaic Lake Valley, Kern County	A 2-square-mile basin drained by Grapevine Creek. Younger alluvium.	Unknown	Unknown	Unknown	Unknown	Unknown
5-80	Brite Valley, Kern County	A 3-square-mile basin drained by Brite Creek. Younger alluvium.	Unknown	Unknown	0–500	15,000	Unknown

GROUND WATER RESOURCES
BASIN
STUDY AREA

Development	Degree of knowledge	Problems
Intensive for irrigation, domestic, industrial, municipal, and stock use. Estimated 1970 pumpage 10 million acre-feet. A potential for high additional development in northern portion of valley, and a limited potential for additional development in the southern portion of the valley.	High for geology, hydrology, and water quality in most of valley, isolated areas of moderate and limited. References: DWR 8, 15, 63, 64, 73, 122, 124, 127, 131, 133, 134, 136, 142, 143, 154, 158; USBR 2, 4, 8; USGS 12, 22, 23, 24, 25, 26, 27, 50, 53, 54, 73, 74, 83, 97, 98, 99, 100, 106, 130, 132; Misc. 7	Much of the Valley is in overdraft condition, which has caused excessive land subsidence along the west side and southern part of the Valley—maximum subsidence of 28 feet southwest of Mendota and extensive dewatering of unconfined aquifers east of the valley trough from Merced Irrigation District to the extreme southern part of the basin. A major water quality problem is the rising saline connate waters in the Sacramento-San Joaquin Delta from Stockton to Tracy. Shallow poor quality water on west side of Valley. High sodium, chloride and sulfate water occur in scattered areas throughout trough of the Valley north of Fresno. High boron concentrations in areas in the Tulare Lake Basin. High nitrates around the Delano area.
Limited for irrigation and domestic use. Potential for additional development is unknown.	Superficial for geology. Limited for hydrology and water quality. References: DWR 46; DMG 1	None known.
Limited for irrigation and domestic use. Potential for additional development is unknown.	Superficial for geology. Limited for hydrology and water quality. References: DMG 5	None known.
Moderate for irrigation use. Limited for domestic use. A potential for limited to moderate additional development.	Superficial for geology. Limited for hydrology and water quality. References: DWR 38	None known.
Limited for irrigation and domestic use. Potential for additional development is unknown.	Superficial for geology, hydrology and water quality. References: DMG 8	None known.
Intensive for irrigation and domestic use. Estimated 1960 pumpage 4,200 AF. No potential for additional development.	Limited for geology, hydrology and water quality. References: DWR 30; Misc. 9	Annual overdraft, 1,700 AF (1960). In February 1974, Tehachapi-Cummings Water Storage District started to receive State Water Project water.
Intensive for irrigation, industrial, municipal and domestic use. Estimated 1960 pumpage 9,500 AF. No potential for additional development.	Limited for geology, hydrology and water quality. References: DWR 34; Misc. 9	Annual overdraft, 5,800 AF (1960). In February 1974, Tehachapi-Cummings Water Storage District started to receive State Water Project water
Limited for irrigation and domestic use. Potential for additional development is unknown.	Superficial for geology, hydrology and water quality. References: DWR 84	None known.
Intensive for irrigation and domestic use. Estimated 1960 pumpage 600 AF. No potential for additional development.	Limited for geology, hydrology and water quality. References: Misc. 9	Annual overdraft of 500 AF (1960).



GROUND WATER BASINS - NORTH LAHONTAN HYDROLOGIC STUDY ARE

NORTH LAHONTAN HYDROLOGIC STUDY AREA

Ground Water Basins

No.	Old No.	Name	County
6-1		Surprise Valley	Lassen, Modoc
6-2		Madeline Plains	Lassen
6-3		Willow Creek Valley	Lassen
6-4		Honey Lake Valley	Lassen
6-5		Tahoe Valley	El Dorado, Placer
6-5.01		Tahoe Valley - South	El Dorado
6-5.02		Tahoe Valley - North	Placer
6-6		Carson Valley	Alpine
6-7		Antelope Valley (Topaz Valley)	Mono
6-8		Bridgeport Valley	Mono
6-67		Martis Valley (Truckee Valley)	Nevada, Placer
6-91		Cow Head Lake Valley	Modoc
6-92		Pine Creek Valley	Lassen
6-93		Harvey Valley	Lassen
6-94		Grasshopper Valley	Lassen
6-95		Dry Valley	Lassen
6-96		Eagle Lake Area	Lassen
6-97		Horse Lake Valley	Lassen
6-98		Tuledad Canyon Area	Lassen
6-99		Painters Flat	Lassen
6-100		Secret Valley	Lassen
6-101		Bull Flat	Lassen
6-102		Modoc Plateau Recent Volcanic Areas	Lassen
6-103		Modoc Plateau Pleistocene Volcanic Areas	Lassen
6-104		Long Valley	Lassen, Sierra
6-105		Slinkard Valley	Mono
6-106		Little Antelope Valley	Mono
6-107		Sweetwater Flat	Mono

Summary

The North Lahontan Hydrologic Study Area (HSA) occupies the northeastern portion of California. A part of the Great Basin, a large region of interior drainage, the HSA lies east of the drainage divide between the Central Valley and the streams flowing either into Nevada or into closed intermittent lakes near the California-Nevada border. The HSA is bounded on the east by Nevada and on the west by the crests of the Sierra Nevada and the Warner Range. From north to south, the HSA extends from the Oregon border to the southern edge of the Walker River Basin in Mono County.

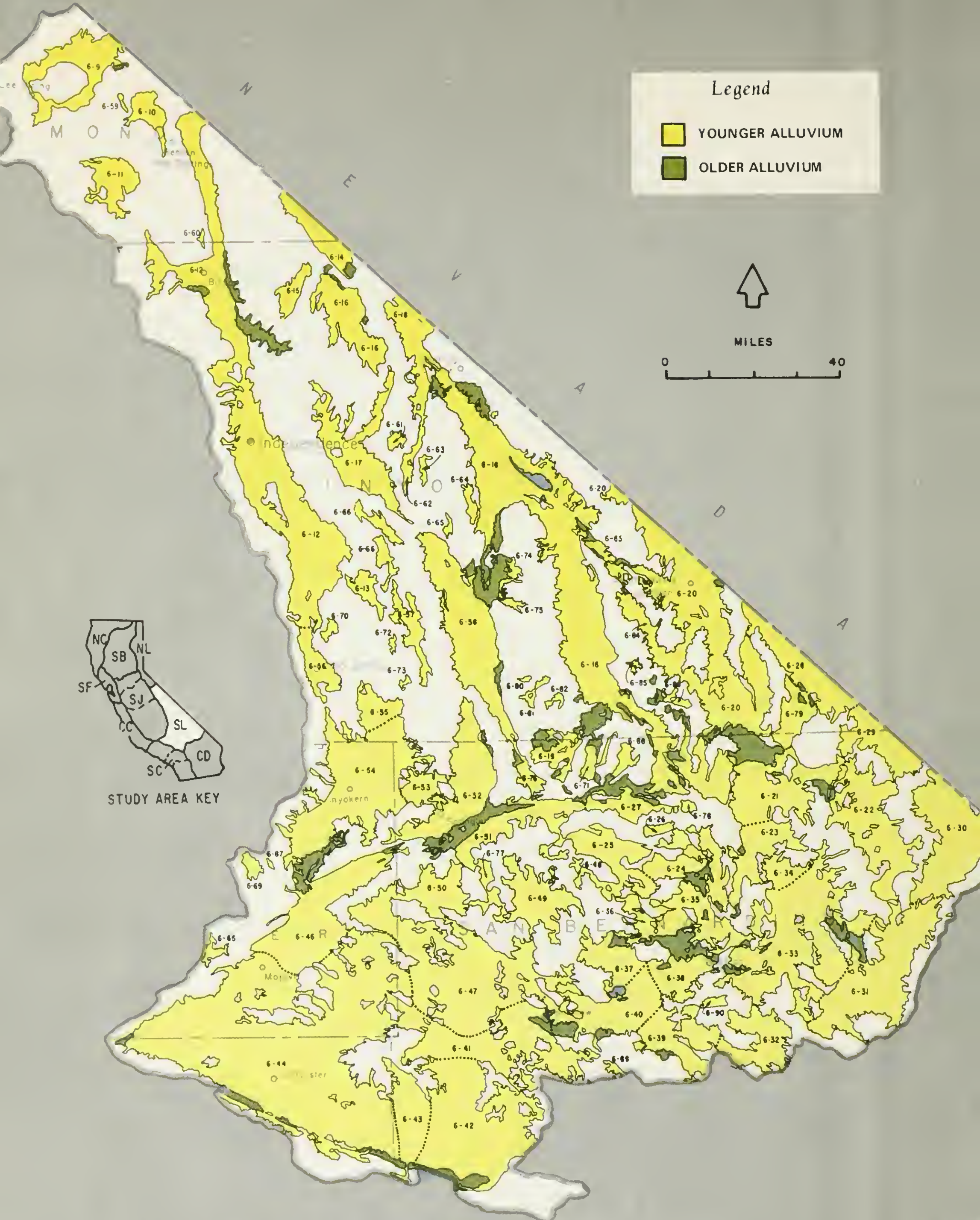
In the HSA, 27 ground water basins, sub-basins and areas of potential ground water storage have been identified. The inventory covers 10 valleys with a total area of about 1,340 square miles which have been identified as significant sources of ground water. The estimated storage capacity of eight of the valleys is about 23.8 million acre-feet. Only one basin, Truckee Valley, has been analyzed to determine its usable storage capacity, which was estimated at 50,000 acre-feet. The maximum yield from an individual well, measured in the Madeline Plains, is about 3,800 gpm; however, the highest average yield of wells, measured in Surprise Valley and Honey Lake Valley, is about 900 gpm.

Minor development of ground water has taken place in most of the basins, and the potential for further development appears promising. Limiting factors include (1) economic considerations, such as the costs of drilling a well and pumping energy, and (2) quality considerations, such as the high mineral concentrations in ground water in parts of the HSA.

Although ground water temperatures normally range from about 50° F to 80°F, temperatures as high as 182°F have been measured in thermal springs in Surprise Valley. TDS is generally lower than 500 mg/1, but in some areas concentrations up to 2,030 mg/1 have been measured. The predominant mineral in the ground water is calcium carbonate; however, sodium, magnesium, chloride, and sulfate are also found locally in significant quantities. Thermal water in Surprise Valley contains significant concentrations of sodium sulfate and sodium chloride.

Basin number	Basin name, county	Basin description: size, major stream, water bearing material	Well yields in gpm		Depth zone in feet	Storage capacity in acre-feet	Usable capacity in acre-feet
			Max.	Aver.			
6-1	Surprise Valley, Lassen and Modoc Counties	A 350-square-mile basin with internal drainage. Younger alluvium.	2,800	900	0–400	4,000,000	Unknown
6-2	Madeline Plains, Lassen County	A 270-square-mile basin with internal drainage. Younger alluvium and older volcanics.	3,800	350	0–600	2,000,000	Unknown
6-3	Willow Creek Valley, Lassen County	A 20-square-mile basin drained by Willow Creek. Younger alluvium and younger and older volcanics.	1,200	Unknown	Unknown	Unknown	Unknown
6-4	Honey Lake Valley, Lassen County	A 490-square-mile basin with internal drainage. Extends into Nevada. Younger alluvium and older volcanics.	2,100	900	0–750	16,000,000	Unknown
6-5	Tahoe Valley						
6-5.01	Tahoe Valley — South, El Dorado County	A 21-square-mile basin drained by the Upper Truckee River. Younger alluvium.	130	80	20–100	84,000	Unknown
6-5.02	Tahoe Valley — North, Placer County	A 4-square-mile basin drained by the Truckee River. Younger alluvium	Unknown	Unknown	Unknown	Estimate included in 6-5.01	Unknown
6-6	Carson Valley, Alpine County	A 20-square-mile basin drained by the Carson River. Younger and older alluvium.	Unknown	Unknown	20–120	100,000	Unknown
6-7	Antelope Valley, (Topaz Valley) Mono County	A 36-square-mile basin drained by West Walker River. Younger alluvium.	Unknown	Unknown	20–120	340,000	Unknown
6-8	Bridgeport Valley, Mono County	A 100-square-mile basin drained by Robinson Creek and the East Walker River. Younger alluvium.	Unknown	Unknown	20–120	280,000	Unknown
6-67	Martis Valley (Truckee Valley), Nevada and Placer Counties	A 25-square-mile basin drained by the Truckee River. Younger alluvium.	3,300	600	10–400	1,000,000	50,000

Development	Degree of knowledge	Problems
Limited for irrigation, domestic, and stock use. 1974 pumpage has no long-term lowering effect on the ground water levels. A potential for moderate additional development.	Limited for geology, hydrology, and water quality. References: DWR 96, 97, 163; USGS 7	Poor quality waters in thermal artesian wells and hot springs.
Limited for irrigation, domestic, and stock use. A potential for limited additional development.	Limited for geology, hydrology and water quality. References: DWR 96, 97, 156	High TDS, excessive iron and boron concentration. Two wells between Termo and Madeline have excessively high chloride, sulfate and nitrate concentration.
Limited for irrigation, domestic and stock use. A potential for moderate additional development.	Limited for geology, hydrology, and water quality. References: DWR 96, 164	None known.
Moderate for irrigation, domestic, and stock use. A potential for high additional development.	Limited for geology, hydrology, and water quality. References: DWR 96, 97, 164; USGS 52	High boron, TDS, fluoride arsenic, sulfate, and percent sodium. Accumulation of salts in basin most serious problem.
Limited for domestic use and irrigation of the recreation areas (golf courses). A potential for high additional development.	Limited for geology, hydrology, and water quality. References: DWR 161; USGS 21	None known.
Limited for domestic use. A potential for limited additional development.	Superficial for geology, hydrology, and water quality. References: USGS 21; Misc. 3	None known.
Limited for irrigation and domestic use. A potential for limited additional development.	Superficial for geology, hydrology, and water quality. References: DWR 58	None known.
Limited for irrigation and domestic use. A potential for moderate additional development.	Limited for geology, hydrology, and water quality. References: DWR 57; Misc. 1, 2	Artesian wells in central portion of the valley contain high boron and fluoride concentrations.
Limited for irrigation, domestic, and stock use. A potential for moderate additional development.	Limited for geology, in north half, superficial in south half. Superficial for hydrology and water quality. References: DWR 145; Misc. 1, 2	None known.
Moderate for municipal and domestic use. Estimate safe yield 20,000 AFY. A potential for moderate additional development.	Moderate in geology, hydrology, and water quality. References: Misc. 3, 14	None known.



GROUND WATER BASINS - SOUTH LAHONTAN HYDROLOGIC STUDY AREA

SOUTH LAHONTAN HYDROLOGIC STUDY AREA

Ground Water Basins

No.	Old No.	Name	County
6-9		Mono Valley	Mono
6-10		Adobe Lake Valley	Mono
6-11		Long Valley	Mono
6-12		Owens Valley	Inyo, Mono
6-13		Black Springs Valley	Inyo
6-14		Fish Lake Valley	Inyo, Mono
6-15		Deep Springs Valley	Inyo
6-16		Eureka Valley	Inyo
6-17		Saline Valley	Inyo
6-18		Death Valley	Inyo, San Bernardino
6-19		Wingate Valley	Inyo, San Bernardino
6-20		Middle Amargosa Valley	Inyo, San Bernardino
6-21		Lower Kingston Valley	San Bernardino
6-22		Upper Kingston Valley	San Bernardino
6-23		Riggs Valley	San Bernardino
6-24		Red Pass Valley	San Bernardino
6-25		Bicycle Valley	San Bernardino
6-26		Avawatz Valley	San Bernardino
6-27		Leach Valley	San Bernardino
6-28		Pahrump Valley	Inyo
6-29		Mesquite Valley	Inyo, San Bernardino
6-30		Ivanpah Valley	San Bernardino
6-31		Kelso Valley	San Bernardino
6-32		Broadwell Valley	San Bernardino
6-33		Soda Lake Valley	San Bernardino
6-34		Silver Lake Valley	San Bernardino
6-35		Cronise Valley	San Bernardino
6-36		Langford Valley	San Bernardino
6-37		Coyote Lake Valley	San Bernardino
6-38		Caves Canyon Valley	San Bernardino
6-39		Troy Valley	San Bernardino
6-40		Lower Mojave River Valley	San Bernardino
6-41		Middle Mojave River Valley	San Bernardino
6-42		Upper Mojave River Valley	San Bernardino
6-43		El Mirage Valley	San Bernardino
6-44		Antelope Valley	Kern, Los Angeles, San Bernardino
6-45		Tehachapi Valley East	Kern
6-46		Fremont Valley	Kern
6-47		Harper Valley	Kern, San Bernardino
6-48		Goldstone Valley	San Bernardino
6-49		Superior Valley	San Bernardino
6-50		Cuddeback Valley	San Bernardino
6-51		Pilot Knob Valley	San Bernardino
6-52		Searles Valley	Inyo, Kern, San Bernardino
6-53		Salt Wells Valley	San Bernardino
6-54		Indian Wells Valley	Inyo, Kern, San Bernardino
6-55		Coso Valley	Inyo
6-56		Rose Valley	Inyo
6-57		Darwin Valley	Inyo
6-58		Panamint Valley	Inyo
6-59		Granite Mountain Area	Mono
6-60		Fish Slough Valley	Inyo, Mono
6-61		Cameo Area	Inyo
6-62		Race Track Valley	Inyo
6-63		Hidden Valley	Inyo
6-64		Marble Canyon Area	Inyo
6-65		Cottonwood Spring Area	Inyo
6-66		Lee Flat	Inyo
6-68		Santa Rosa Flat	Inyo
6-69		Kelso Lander Valley	Kern
6-70		Cactus Flat	Inyo
6-71		Lost Lake Valley	San Bernardino
6-72		Coles Flat	Inyo
6-73		Wild Horse Mesa Area	Inyo
6-74		Harrisburg Flats	Inyo
6-75		Wildrose Canyon	Inyo
6-76		Brown Mountain Valley	San Bernardino
6-77		Grass Valley	San Bernardino
6-78		Denning Spring Valley	San Bernardino
6-79		California Valley	Inyo, San Bernardino
6-80		Middle Park Canyon	Inyo
6-81		Butte Valley	Inyo
6-82		Spring Canyon Valley	Inyo
6-83		Furnace Creek Area	Inyo
6-84		Greenwater Valley	Inyo
6-85		Gold Valley	Inyo
6-86		Rhodes Hill Area	Inyo
6-87		Butterbread Canyon Valley	Kern
6-88		Owl Lake Valley	San Bernardino
6-89		Kane Wash Area	San Bernardino
6-90		Cady Fault Area	San Bernardino

Summary

The South Lahontan Hydrologic Study Area (HSA), which is primarily desert, is drained internally with no outlet to the ocean. Three important rivers which flow throughout the year, at least in their upper reaches, are the Owens, Mojave, and Amargosa.

In the South Lahontan HSA, 81 ground water basins and areas of potential ground water storage have been identified. The inventory covers 55 ground water basins. These 55 basins, with a total area of about 13,600 square miles have been identified as significant sources of ground water. The water-bearing deposits range in thickness up to 2,000 feet.

Total storage capacity for 50 of the basins, within selected depth intervals, is about 246.8 million acre-feet. Usable storage capacity of two basins is estimated to be about 11.2 million acre-feet. One major limiting

INVENTORY OF SOUTH HYDROLOGIC

Basin number	Basin name, county	Basin description: size, major stream, water bearing material	Well yields in gpm		Depth zone in feet	Storage capacity in acre-feet	Usable capacity in acre-feet
			Max.	Aver.			
6-9	Mono Valley, Mono County	A 250-square-mile basin with with internal drainage. Younger alluvium and glacial deposits.	80	35	20–220	3,400,000	Unknown
6-10	Adobe Lake Valley, Mono County	A 60-square-mile basin with internal drainage. Younger alluvium.	Unknown	Unknown	20-120	320,000	Unknown
6-11	Long Valley, Mono County	A 120-square-mile basin containing the head-waters of the Owens River. Younger alluvium and glacial deposits.	250	90	20–120	160,000	Unknown
6-12	Owens Valley, Inyo and Mono Counties	A 1,030-square-mile basin drained by the Owens River. Younger and older alluvium, and glacial deposits.	9,000	1,500+	20–1,000	30,000,000	Unknown
6-13	Black Springs Valley, Inyo County	A 50-square-mile basin tributary to Owens Valley. Younger alluvium.	Unknown	Unknown	20–120	230,000	Unknown
6-14	Fish Lake Valley, Inyo and Mono Counties	A 70-square-mile basin drained by Cottonwood Creek. Extends into Nevada. Younger and older alluvium.	Unknown	Unknown	50–150	320,000	Unknown
6-15	Deep Springs Valley, Inyo County	A 40-square-mile basin with internal drainage. Younger alluvium.	700	390	20–220	740,000	Unknown
6-16	Eureka Valley, Inyo County	A 160-square-mile basin with internal drainage. Younger and older alluvium.	Unknown	Unknown	100–300	2,070,000	Unknown
6-17	Saline Valley, Inyo County	A 210-square-mile basin with internal drainage. Waucoba Wash main drainage channel. Younger alluvium.	Unknown	Unknown	20–220	2,430,000	Unknown
6-18	Death Valley, Inyo and San Bernardino Counties	A 1,320-square-mile basin with internal drainage. Major drainage channels are Salt Creek, Wingate Wash and Amargosa River. Younger and older alluvium.	Unknown	Unknown	20–220	11,000,000	Unknown

factor affecting usable storage capacity is the occurrence of saline deposits within the sediments in many of the ground water basins.

Ground water temperatures generally range from about 50° to 86° F, but temperatures as high as 240°F have been recorded in Coso Hot Springs. Although the TDS content of the water varies considerably from basin to basin and within some basins, much of the water contains less than 600 mg/l. In Searles dry lake, a soft playa, TDS of the brine is in excess of 400,000 mg/l. The fresh water supply for the valley is obtained from springs flanking the valley and from imported water.

Ground water in Owens Valley is pumped to meet local water demands and for export to Los Angeles. An environmental impact report is being processed on a proposal to increase the long-term average pumping yield to 130,000 acre-feet per year.

Valleys in which large volumes of ground water are used are Antelope, Indian Wells, Fremont, and Upper, Middle and Lower Mojave River.

GROUND WATER RESOURCES LAHONTAN STUDY AREA

Development	Degree of knowledge	Problems
Limited for domestic, industrial, and livestock use. A limited potential for additional development.	Superficial for geology and hydrology. Limited for water quality. References: DWR 112, 155; USGS 59	Locally, poor quality for domestic and irrigation use. High TDS, boron and percent sodium.
Limited for irrigation and domestic use. A potential for limited additional development.	Superficial for geology and hydrology. Limited for water quality. References: DWR 112; Misc. 17	None known.
Limited for domestic, industrial, and irrigation use. A potential for limited additional development.	Moderate for geology in west and limited in east. Limited for hydrology and water quality. References: DWR 112, 181, 191	Locally poor quality for domestic and irrigation use. High fluoride, boron, percent sodium, and arsenic from hot springs.
Limited for ground water export, irrigation, industrial, livestock, and domestic use. A high potential for additional development.	Limited to moderate for geology and water quality. High for hydrology. References: DWR 112, 125; USGS 70; Misc. 20	High fluoride, boron, and percent sodium.
Limited for livestock use. Insignificant use of ground water. A potential for limited additional development.	Superficial for geology, hydrology, and water quality. References: DWR 112	None known.
Limited for domestic, irrigation, and livestock use. A potential for limited additional development.	Limited for geology, hydrology and water quality. References: DWR 112; Misc. 4, 12	Locally fluoride marginal for domestic use.
Limited for irrigation, domestic, and livestock use. A potential for limited additional development.	Superficial for geology and hydrology. Limited for water quality. References: DWR 112	Locally fluoride marginal for domestic use.
None. Although not determined, may have a high potential for development.	Superficial for geology, hydrology, and water quality. References: DWR 112	None known.
None. Although not determined, may have a high potential for development.	Superficial for geology, hydrology, and water quality. References: DWR 112	Locally fluoride, chloride, sulfate, and TDS high for domestic use; boron and percent sodium high for irrigation.
Limited for domestic and irrigation uses. A potential for moderate to high additional development. Major source of water from springs.	Limited for geology, hydrology and water quality in center and superficial at ends. References: DWR 112; USGS 56, 64, 101	Locally poor quality for domestic and irrigation use. High fluoride, boron, chloride, sulfate, TDS and percent sodium.

Basin number	Basin name, county	Basin description: size, major stream, water bearing material	Well yields in gpm		Depth zone in feet	Storage capacity in acre-feet	Usable capacity in acre-feet
			Max.	Aver.			
6-19	Wingate Valley, Inyo and San Bernardino Counties	A 70-square-mile basin drained by Wingate Wash. Younger and older alluvium.	Unknown	Unknown	100–300	870,000	Unknown
6-20	Middle Amargosa Valley, Inyo and San Bernardino Counties	A 620-square-mile basin drained by the Amargosa River. Younger and older alluvium.	3,000	2,500	20–220	6,800,000	Unknown
6-21	Lower Kingston Valley, San Bernardino County	A 290-square-mile basin drained by unnamed streams. Younger and older alluvium.	Unknown	Unknown	100–300	3,390,000	Unknown
6-22	Upper Kingston Valley, San Bernardino County	A 270-square-mile basin drained by Kingston Wash. Younger alluvium.	24	Unknown	50–250	2,130,000	Unknown
6-23	Riggs Valley, San Bernardino County	A 100-square-mile basin with internal drainage. Younger alluvium.	Unknown	Unknown	100–300	1,190,000	Unknown
6-24	Red Pass Valley, San Bernardino County	A 150-square-mile basin drained by unnamed streams. Younger and older alluvium.	Unknown	Unknown	100–300	870,000	Unknown
6-25	Bicycle Valley, San Bernardino County	A 120-square-mile basin with internal drainage. Younger alluvium.	700	Unknown	100–300	1,700,000	Unknown
6-26	Avawatz Valley, San Bernardino County	A 70-square-mile basin drained by unnamed streams. Younger alluvium.	Unknown	Unknown	100–300	580,000	Unknown
6-27	Leach Valley, San Bernardino County	A 70-square-mile basin with internal drainage. Younger and older alluvium.	Unknown	Unknown	20–220	650,000	Unknown
6-28	Pahrump Valley, Inyo County	A 400-square-mile basin with internal drainage. Extends into Nevada. Younger alluvium.	300	150	100–300	690,000	Unknown
6-29	Mesquite Valley, Inyo and San Bernardino Counties.	A 120-square-mile basin with internal drainage. Younger alluvium.	1,500	1,020	20–220	580,000	Unknown
6-30	Ivanpah Valley, San Bernardino County	A 300-square-mile basin with internal drainage. Extends into Nevada. Younger alluvium.	600	400	20–220	3,090,000	Unknown
6-31	Kelso Valley, San Bernardino County	A 370-square-mile basin drained by Kelso Wash. Younger and older alluvium.	370	290	200 400	5,340,000	Unknown
6-32	Broadwell Valley, San Bernardino County	A 120-square-mile basin drained by unnamed streams. Younger alluvium.	Unknown	Unknown	100–300	1,220,000	Unknown

GROUND WATER RESOURCES LAHONTAN AREA—Continued

Development	Degree of knowledge	Problems
None. May have a potential for limited to moderate additional development.	Superficial for geology, hydrology, and water quality. References: DWR 112	None known.
Limited for domestic, irrigation, and industrial use. A potential for moderate to high additional development.	Limited for geology, hydrology, water quality. References: DWR 112; USBR 16; Misc. 19	Locally poor quality for domestic and irrigation use. High fluoride, boron, sulfate, and percent sodium.
None. A potential for moderate to high additional development.	Superficial for geology and hydrology. Limited for water quality. References: DWR 112	Locally poor quality for domestic and irigation use.
Limited for domestic and livestock use. A potential for moderate additional development.	Superficial for geology, hydrology, and water quality. References: DWR 112	Locally spring water is of poor quality for irrigation and domestic use. High fluoride, boron, chloride, TDS, sulfate, and percent sodium.
None. A potential for limited additional development.	Superficial for geology, hydrology, and water quality. References: DWR 112	None known.
None. A potential for limited additional development.	Superficial for geology, hydrology, and water quality. References: DWR 112	None known.
Limited for military use. A potential for limited additional development.	Limited for geology and superficial for hydrology and water quality. References: DWR 112; USGS 61	None known.
None. A limited potential for additional development.	Superficial for geology, hydrology, and water quality. References: DMG 3; USGS 118	None known.
None. A potential for limited additional development.	Superficial for geology, hydrology, and water quality. References: DWR 112; USGS 118	None known.
Limited irrigation and domestic use. A potential for limited additional development.	Moderate for geology. Limited for hydrology and water quality. References: DWR 42, 112; USGS 78, 127	None known.
Limited for irrigation and domestic use. A potential for limited additional development.	Limited for geology, hydrology, and water quality. References: DWR 42, 112; USGS 127; Misc. 5.	Locally unsuitable for domestic and irrigation use.
Limited for industrial, irrigation, domestic, and stock use. A potential for moderate additional development.	Superficial for geology and hydrology. Limited for water quality. References: DWR 94, 112; USGS 127	Poor quality.
Limited for domestic, irrigation, and industrial use. A potential for moderate to high additional development.	Superficial for geology and hydrology. Limited for water quality. References: DWR 112	Locally unsuitable for beneficial use.
Limited for domestic and irrigation use. A potential for limited additional development.	Superficial for geology and hydrology. Limited for water quality. References: DWR 87, 112	Locally poor quality for domestic use.

Basin number	Basin name, county	Basin description: size, major stream, water bearing material	Well yields in gpm		Depth zone in feet	Storage capacity in acre-feet	Usable capacity in acre-feet
			Max.	Aver.			
6-33	Soda Lake Valley, San Bernardino County	A 590-square-mile basin drained by the Mojave River. Younger alluvium.	2,100	1,100	20–220	9,300,000	Unknown
6-34	Silver Lake Valley, San Bernardino County	A 40-square-mile basin with internal drainage. Younger alluvium.	Unknown	Unknown	50–250	380,000	Unknown
6-35	Cronise Valley, San Bernardino County	A 150-square-mile basin with internal drainage. Younger and older alluvium.	600	340	20–220	1,000,000	Unknown
6-36	Langford Valley, San Bernardino County	A 50-square-mile basin drained by unnamed streams. Younger and older alluvium.	690	410	100–300	760,000	Unknown
6-37	Coyote Lake Valley, San Bernardino County	A 150-square-mile basin with internal drainage. Younger and older alluvium.	1,740	660	1961 water level to base of fresh water-bearing unit	7,530,000	Unknown
6-38	Caves Canyon Valley, San Bernardino County	A 100-square-mile basin drained by the Mojave River. Younger and older alluvium.	300	Unknown	1961 water level to base of fresh water-bearing unit	4,152,000	Unknown
6-39	Troy Valley, San Bernardino County	A 130-square-mile basin with drainage tributary to the Mojave River. Younger alluvium.	1,700	300	20–220	2,170,000	Unknown
6-40	Lower Mojave River Valley, San Bernardino County	A 300-square-mile basin drained by the Mojave River. Younger and older alluvium.	1,700	560	20–220	5,100,000	Unknown
6-41	Middle Mojave River Valley, San Bernardino County	A 430-square-mile basin drained by the Mojave River. Younger and older alluvium.	1,500	500	1961 water level to base of water-bearing unit.	8,048,000	3,000,000+ (Ground surface to 1961 water level)
6-42	Upper Mojave River Valley, San Bernardino County	A 600-square-mile basin drained by the Mojave River. Younger and older alluvium.	3,600	630	1961 water level to base of water-bearing unit.	26,532,000	8,200,000+ (Ground surface to 1961 water level)
6-43	El Mirage Valley, San Bernardino County	A 120-square-mile basin drained by Sheep Creek. Younger and older alluvium.	1,000	230	20–220	1,760,000	Unknown

Development	Degree of knowledge	Problems
Limited for municipal, irrigation, industrial and domestic use. A potential for moderate to high additional development.	Superficial for geology and hydrology. Limited for water quality. References: DWR 86, 112	Locally fluoride and TDS high for domestic use; percent sodium high for irrigation use.
Limited for domestic use. A potential for limited additional development.	Superficial for geology and hydrology. Limited for water quality. References: DWR 86, 112	Locally water quality unsuitable for domestic and irrigation use.
None. A potential for limited to moderate additional development.	Superficial for geology and hydrology. Limited for water quality. References: DWR 86, 112	Poor quality locally for domestic and irrigation use.
Limited for military use. A potential for limited additional development.	Limited for geology, hydrology, and water quality. References: DWR 112; USGS 61	Locally fluoride and iron high for domestic use.
Limited for irrigation and domestic use. A potential for moderate to high additional development.	Limited for geology, hydrology, and water quality. References: DWR 71, 83, 112; USGS 61	Locally fluoride and TDS high for domestic use. Quality poor for irrigation.
Limited for domestic use. A potential for moderate additional development.	Superficial for geology and hydrology. Limited for water quality. References: DWR 71, 83, 112	Locally quality poor for domestic use.
Limited for domestic, irrigation and industrial use. A potential for moderate additional development.	Limited for geology, hydrology, and water quality in west, superficial in east. References: DWR 71, 83, 112; USGS 47	Locally quality poor for domestic and irrigation use.
Moderate for municipal, and irrigation use. Limited for domestic and industrial use. Recharge under 1960–61 cultural conditions, 5,600 AF. A potential for moderate additional development.	Moderate for geology, hydrology, and water quality in west and limited in east. References: DWR 20, 71, 83, 112; USBR 13; USGS 47, 55, 112	Large area downstream of Barstow of poor quality for domestic use. Overdraft.
Moderate for irrigation use. Limited for municipal, industrial, and domestic use. Recharge under 1960–61 cultural conditions 21,900 AF. 1960–61 extractions, 32,000 AF. A potential for moderate to high additional development.	Limited for geology, hydrology, and water quality. References: DWR 20, 71, 74, 76, 112; USBR 13; USGS 47	Locally quality poor for domestic and irrigation use. Overdraft.
Moderate for irrigation, military, and municipal use. Limited for domestic and industrial use. Recharge under 1960–61 cultural conditions. 43,600 AF: extractions 57,000 AF. A potential for moderate additional development.	Limited for geology, hydrology, and water quality. References: DWR 20, 71, 74, 112; USBR 13; USGS 47	Locally quality poor for domestic use. Overdraft.
Limited for irrigation, industrial, and domestic use. A potential for moderate additional development.	Superficial for geology and limited for hydrology, and water quality. References: DWR 112; USGS 6	Locally quality poor for domestic and irrigation use.

Basin number	Basin name, county	Basin description: size, major stream, water bearing material	Well yields in gpm		Depth zone in feet	Storage capacity in acre-feet	Usable capacity in acre-feet
			Max.	Aver.			
6-44	Antelope Valley, Kern, Los Angeles, and San Bernardino Counties	A 1,620-square-mile basin with primarily internal drainage. Major drainage channels are Littlerock and Big Rock Creeks. Younger and older alluvium.	3,250	770	Average ground surface elevation to base of fresh water	70,000,000	+Unknown
6-45	Tehachapi Valley-East, Kern County	A 20-square-mile basin drained by Cache Creek. Younger alluvium.	2,500	1,500	100–300	138,000	Unknown
6-46	Fremont Valley, Kern County	A 330-square-mile basin with internal drainage. Younger and older alluvium.	2,580	530	20–220	4,800,000	Unknown
6-47	Harper Valley, Kern and San Bernardino Counties	A 510-square-mile basin with internal drainage. Younger alluvium.	3,000	725	1961 water level to base of fresh water	6,975,000	Unknown
6-48	Goldstone Valley, San Bernardino County	A 30-square-mile basin with internal drainage. Younger alluvium.	Unknown	Unknown	100–300	210,000	Unknown
6-49	Superior Valley, San Bernardino County	A 170-square-mile basin with internal drainage. Younger alluvium.	450	100	100–300	1,750,000	Unknown
6-50	Cuddeback Valley, San Bernardino County	A 130-square-mile basin with internal drainage. Younger alluvium.	550	300	100–300	1,380,000	Unknown
6-51	Pilot Knob Valley, San Bernardino County	A 200-square-mile basin drained by unnamed streams. Younger and older alluvium.	550	300	100–300	2,460,000	Unknown
6-52	Searles Valley, Inyo, Kern, and San Bernardino Counties	A 250-square-mile basin with internal drainage. Younger and older alluvium.	1,000	300	20–220	2,140,000	Unknown
6-53	Salt Wells Valley, San Bernardino County	A 30-square-mile basin drained by unnamed streams. Younger alluvium.	Unknown	Unknown	20–220	320,000	Unknown
6-54	Indian Wells Valley, Inyo, Kern, and San Bernardino Counties	A 520-square-mile basin with internal drainage. Younger and older alluvium.	3,800	815	20–220	5,120,000	Unknown
6-55	Coso Valley, Inyo County	A 50-square-mile basin drained by unnamed streams. Younger alluvium.	Unknown	Unknown	20–250	390,000	Unknown

GROUND WATER RESOURCES
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AREA—Continued

Development	Degree of knowledge	Problems
Intensive for irrigation and municipal use. Moderate for military and industrial use. Limited for domestic and recreation use. Safe yield about 58,000 AFY. 1970 extractions about 200,000 AF. A potential for moderate to high additional development.	Moderate for geology, hydrology, and water quality. References: DWR 43, 79, 85, 112; SWRCB 2; USGS 13, 31, 71	Locally quality poor for irrigation and domestic use. Overdraft. Failing septic tanks.
Moderate to intensive for irrigation use. Moderate for industrial. Limited for domestic and municipal use. A potential for limited additional development.	Limited for geology, hydrology, and water quality. References: DWR 112; Misc. 9	Locally fluoride high for domestic use.
Moderate for irrigation use, and limited for domestic and industrial use. A potential for moderate additional development.	Moderate for geology, hydrology, and water quality. References: DWR 77, 89, 112; USGS 13, 19, 31	Locally poor quality for domestic and irrigation use.
Moderate for irrigation use and limited for industrial and domestic use. A potential for moderate to high additional development.	Superficial for geology. Limited for hydrology and water quality. References: DWR 92, 112	Locally poor quality for irrigation and domestic use.
Limited for military use. A potential for moderate additional development.	Superficial for geology and hydrology. Limited for water quality. References: DWR 92, 112	Locally poor quality for domestic and irrigation use.
Limited for domestic and stock use. A potential for moderate additional development.	Superficial for geology and hydrology. Limited for water quality. References: DWR 92, 112	Locally poor quality for domestic and irrigation use.
Limited for military use. A potential for moderate to high additional development.	Superficial for geology and hydrology. Limited for water quality. References: DWR 92, 112	Locally poor quality for domestic and irrigation use.
Limited for military use. A potential for moderate additional development.	Superficial for geology and hydrology. Limited for water quality. References: DWR 90, 112	Locally poor quality for domestic use.
Moderate to high for industrial use (extraction of salts). Limited for domestic use. Water imported from Indian Wells Valley. A potential for limited additional development.	Moderate for geology and hydrology in center and superficial at ends. Limited for water quality. References: DWR 90, 112; USBR 15; USGS 48	Locally poor quality for domestic and irrigation use.
None. A potential for limited additional development.	Superficial for geology and hydrology. Limited for water quality. References: DWR 90, 112	Locally poor quality for domestic and irrigation use.
Moderate for municipal and irrigation use. Limited for domestic and industrial use. Natural recharge about 10,000 AFY. 1968 extractions about 12,500 AF. A potential for limited additional development.	Moderate for geology, hydrology and water quality in center and superficial at ends. References: DWR 82, 112; USGS 14, 36, 65	Locally poor quality for domestic and irrigation use. High chloride, boron, and TDS.
None. A potential for limited additional development.	Superficial for geology, hydrology and water quality. References: DWR 82, 112; USGS 65	None known.

Basin number	Basin name, county	Basin description: size, major stream, water bearing material	Well yields in gpm		Depth zone in feet	Storage capacity in acre-feet	Usable capacity in acre-feet
			Max.	Aver.			
6-56	Rose Valley, Inyo County	A 60-square-mile basin drained by unnamed streams. Younger alluvium.	2,700	Unknown	20–220	820,000	Unknown
6-57	Darwin Valley, Inyo County	A 70-square-mile basin drained by Darwin Wash. Younger alluvium.	130	43	100–300	400,000	Unknown
6-58	Panamint Valley, Inyo County	A 360-square-mile basin with internal drainage. Younger and older alluvium.	35	30	20–220	3,400,000	Unknown
6-69	Kelso Lander Valley, Kern County	A 17-square-mile basin drained by Cottonwood Creek. Younger alluvium.	Unknown	Unknown	Unknown	Unknown	Unknown
6-71	Lost Lake Valley, San Bernardino County	A 30-square-mile basin with internal drainage. Younger and older alluvium.	Unknown	Unknown	Unknown	Unknown	Unknown
6-76	Brown Mountain Valley, San Bernardino County	A 30-square-mile basin drained by unnamed streams. Younger and older alluvium.	Unknown	Unknown	Unknown	Unknown	Unknown
6-77	Grass Valley, San Bernardino County	A 30-square-mile basin drained by unnamed streams. Younger alluvium.	Unknown	Unknown	Unknown	Unknown	Unknown
6-79	California Valley, Inyo and San Bernardino Counties	A 60-square-mile basin drained by unnamed streams. Younger and older alluvium.	Unknown	Unknown	Unknown	Unknown	Unknown

Development	Degree of knowledge	Problems
Moderate for agriculture. Limited for domestic and industrial use. A potential for limited additional development.	Superficial for geology and hydrology. Limited for water quality. References: DWR 82, 112; USGS 65	Locally poor quality for domestic use.
Limited for domestic and mining use. A potential for limited additional development.	Superficial for geology and hydrology. Limited for water quality. References: DWR 112	None known.
Limited for domestic use. A potential for moderate to high additional development.	Superficial for geology and hydrology. Limited for water quality. References: DWR 90, 112	Locally poor quality for domestic and irrigation use.
Limited for industrial, domestic, and livestock use. 1963 extractions estimated at 5 AF. A potential for limited additional development.	Superficial for geology, hydrology, and water quality. References: DWR 112	Locally fluoride and TDS high for domestic use.
None. A potential for limited additional development.	Superficial for geology, hydrology, and water quality. References: DWR 112	None known.
None. A potential for limited additional development.	Superficial for geology, hydrology, and water quality. References: DWR 112	None known.
Limited for livestock use. A potential for limited additional development.	Superficial for geology and hydrology. Limited for water quality. References: DWR 112	None known.
Limited for domestic, mining and livestock use. A potential for limited additional development.	Superficial for geology and hydrology. Limited for water quality. References: DWR 112; DMG 2, 3	Locally fluoride marginal for domestic use.

GROUND WATER BASINS - COLORADO DESERT HYDROLOGIC STUDY AREA

COLORADO DESERT HYDROLOGIC STUDY AREA

Ground Water Basins

No.	Old No.	Name	County	No.	Old No.	Name	County
7-1		Lanfair Valley	San Bernardino	7-28		Vallecito-Carrizo Valley	Imperial, San Diego
7-2		Fenner Valley	San Bernardino	7-29		Coyote Wells Valley	Imperial, San Diego
7-3		Ward Valley	Riverside, San Bernardino	7-30		Imperial Valley	Imperial
				7-31		Orcopia Valley	Riverside
				7-32		Chocolate Valley	Riverside
7-4		Rice Valley	Riverside, San Bernardino	7-33		East Salton Sea Basin	Imperial, Riverside
				7-34		Amos Valley	Imperial
7-5		Chuckwalla Valley	Imperial, Riverside	7-35		Ogilby Valley	Imperial
				7-36		Yuma Valley	Imperial
7-6		Pinto Valley	Riverside, San Bernardino	7-37		Arroyo Seco Valley	Imperial, Riverside
				7-38		Palo Verde Valley	Imperial, Riverside
7-7		Cadiz Valley	Riverside, San Bernardino	7-39		Palo Verde Mesa	Imperial, Riverside
7-8		Bristol Valley	San Bernardino	7-40		Quien Sabe Point Valley	Riverside
				7-41		Calzona Valley	Riverside, San Bernardino
7-9		Dale Valley	Riverside, San Bernardino	7-42		Vidal Valley	Riverside, San Bernardino
7-10		Twentynine Palms Valley	San Bernardino				
7-11		Copper Mountain Valley	San Bernardino	7-43		Chemehuevi Valley	San Bernardino
7-12		Warren Valley	San Bernardino	7-44		Needles Valley	San Bernardino
7-13		Deadman Valley	San Bernardino	7-45		Piute Valley	San Bernardino
7-14		Lavic Valley	San Bernardino	7-46		Canebrake Valley	San Diego
				7-47		Jacumba Valley	San Diego
7-15		Bessemer Valley	San Bernardino	7-48		Helendale Fault Valley	San Bernardino
7-16		Ames Valley	San Bernardino	7-49		Pipes Canyon Fault Valley	San Bernardino
7-17		Means Valley	San Bernardino	7-50		Iron Ridge Area	San Bernardino
7-18		Johnson Valley	San Bernardino	7-51		Lost Horse Valley	Riverside, San Bernardino
7-19		Lucerne Valley	San Bernardino	7-52		Pleasant Valley	Riverside
7-20		Morongo Valley	San Bernardino	7-53		Hexie Mountain Area	Riverside
				7-54		Buck Ridge Fault Valley	Riverside
7-21		Coachella Valley	Imperial, Riverside	7-55		Collins Valley	Riverside, San Diego
7-22		West Salton Sea Basin	Imperial	7-56		Yaqui Well Area	San Diego
7-23		Clark Valley	San Diego	7-57		Pinyon Wash Area	San Diego
7-24		Borrego Valley	San Diego	7-58		Whale Peak Area	San Diego
7-25		Ocotillo Valley	Imperial, San Diego	7-59		Mason Valley	San Diego
				7-60		Jacumba Valley-East	Imperial, San Diego
7-26		Terwilliger Valley	Riverside				
7-27		San Felipe Valley	San Diego	7-61		Davies Valley	Imperial

Summary

The Colorado Desert Hydrologic Study Area (HSA), includes basins tributary to the Colorado and Whitewater Rivers and numerous smaller drainage channels, some of which drain internally. The Whitewater, New, and Alamo Rivers, and San Felipe Creek are the larger channels draining into the Salton Sea.

In the HSA, 61 ground water basins and areas of potential ground water storage have been identified. The inventory covers 46 ground water basins. These 46 basins, with a total area of about 12,500 square miles, have been identified as significant sources of ground water. The water-bearing deposits range in thickness up to 2,800 feet. In some basins flowing wells have been recorded.

Total storage capacity of 42 basins at selected depth intervals is about 162.8 million acre-feet. The estimated usable storage capacity in 7 basins is about 10.3 million acre-feet.

INVENTORY OF COLORADO HYDROLOGIC

Basin number	Basin name, county	Basin description: size, major stream, water bearing material	Well yields in gpm		Depth zone in feet	Storage capacity in acre-feet	Usable capacity in acre-feet
			Max.	Aver.			
7-1	Lanfair Valley, San Bernardino County	A 280-square-mile basin drained by unnamed streams. Younger alluvium.	35	16	100–300	3,000,000	Unknown
7-2	Fenner Valley, San Bernardino County	A 720-square-mile basin drained by unnamed streams. Younger and older alluvium.	200	100	150–350	5,600,000	Unknown
7-3	Ward Valley, Riverside and San Bernardino Counties	A 770-square-mile basin. Drainage internal under low surface water flows. Younger alluvium.	260	180	100–300	8,700,000	Unknown
7-4	Rice Valley, Riverside and San Bernardino Counties	A 300-square-mile basin drained by unnamed streams. Younger alluvium.	65	Unknown	100–300	2,280,000	Unknown
7-5	Chuckwalla Valley, Imperial and Riverside Counties	A 870-square-mile basin. Drainage internal under low surface water flows. Younger alluvium.	3,900	1,800	20–220	9,100,000	900,000 400-foot pumplift, 100 feet of saturated sediments
7-6	Pinto Basin, Riverside and San Bernardino Counties	A 310-square-mile basin drained by unnamed streams. Younger alluvium.	1,480	900	0–100	230,000	130,000 400-foot pumplift, 100 feet of saturated sediments.
7-7	Cadiz Valley, Riverside and San Bernardino Counties	A 430-square-mile basin. Drainage internal under low surface water flows. Younger alluvium.	167	66	20–220	4,300,000	Unknown
7-8	Bristol Valley, San Bernardino County	A 710-square-mile basin with internal drainage. Younger and older alluvium.	500	125	20–220	7,000,000	Unknown
7-9	Dale Valley, San Bernardino County	A 260-square-mile basin with internal drainage. Younger alluvium.	380	275	20–220	2,000,000	Unknown

Ground water temperatures range from about 60° to about 90°F; however, a temperature in excess of 200°F has been recorded in a well in Coachella Valley. The TDS content of the water varies considerably from basin to basin. In most basins it is less than 600 mg/l. In other basins the dissolved solids content ranges into thousands of milligrams per liter. The highest recorded content is 304,000 mg/l.

The predominant character of the water is sodium sulfate or sodium chloride, but significant quantities of calcium and bicarbonate are also present at some places.

Coachella Valley is one of the most highly developed ground water basins in the study area. In 1970, applied ground water for irrigation of 6,600 acres was 41,100 acre-feet. Urban use by the resident population of 103,700 during the same period amounted to 45,300 acre-feet. In addition, about 350,000 acre-feet of Colorado River is used each year, primarily for irrigation.

Ground water extractions in the HSA are estimated at about 185,000 acre-feet.

GROUND WATER RESOURCES DESERT STUDY AREA

Development	Degree of knowledge	Problems
Limited for livestock and domestic use. Natural recharge about 1800 AFY. Extractions negligible. A potential for limited to moderate additional development.	Superficial for geology and limited for hydrology and water quality. References: DWR 40, 42; USGS 117	Locally water high in sulfate and TDS, unsuitable for domestic use. Locally unsuitable for irrigation use.
Limited for livestock, domestic and industrial use. Natural recharge estimated at about 3000 AFY. 1952 extractions estimated at about 7.0 AF. A potential for limited to moderate additional development.	Superficial for geology and hydrology. Limited for water quality. References: DWR 40, 42	None known.
Limited for livestock and domestic use. Natural recharge estimated at about 2700 AFY. 1952 extractions estimated at about 2 AF. A potential for moderate additional development.	Superficial for geology and hydrology. Limited for water quality. References: DWR 40, 87	Locally TDS, sulfate, fluoride, and chloride, high for domestic use. Saline water near Danby dry lake. Locally unsuitable for irrigation use.
Limited for domestic use. Natural recharge estimated at about 500 AFY. 1952 extractions estimated at about 1 AF. A potential for limited to moderate additional development.	Superficial for geology and hydrology. Limited for water quality. References: DWR 40, 81	Locally chloride, TDS, fluoride, and sulfate high for domestic use; boron high for irrigation use.
Limited for agriculture and domestic use. 1952 extractions 11 AF. A potential for limited to moderate additional development.	Superficial for geology and hydrology. Limited for water quality. References: DWR 40, 42, 80; USBR 18	Locally sulfate, chloride, fluoride, and TDS high for domestic use; boron, TDS, and percent sodium high for irrigation use.
Limited for domestic and industrial use. 1952 extractions estimated at about 320 AF. A potential for limited to moderate additional development.	Limited for geology and hydrology in east and superficial in west. Limited for water quality. References: DWR 40; USBR 18; USGS 63	Locally fluoride high for domestic use; percent sodium high for irrigation use.
Limited for domestic use. Natural recharge estimated at about 800 AFY. 1952 extractions about 1 AF. A potential for moderate to high additional development.	Superficial for geology and hydrology. Limited for water quality. References: DWR 40, 87	Poor quality in the vicinity of Cadiz dry lake.
Limited for domestic and moderate for industrial use. Natural recharge estimated at about 2100 AFY. 1952 extractions about 11 AF. A potential for limited to moderate additional development.	Superficial for geology and hydrology. Limited for water quality. References: DWR 40, 87	Poor quality northwest of Bristol dry lake. High fluorides along northeast boundary of valley.
Limited for domestic, irrigation, and industrial use. Natural recharge estimated at about 900 AFY. 1952 extractions about 1 AF. A potential for limited to moderate additional development.	Superficial for geology and hydrology. Limited for water quality. References: DWR 40, 78; USBR 14	Poor quality in the vicinity of Dale dry lake.

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Basin number	Basin name, county	Basin description: size, major stream, water bearing material	Well yields in gpm		Depth zone in feet	Storage capacity in acre-feet	U ca ac
			Max.	Aver.			
7-10	Twentynine Palms Valley, San Bernardino County	A 180-square-mile basin with internal drainage. Younger alluvium.	600	220	20–220	1,420,000	Un
7-11	Copper Mountain Valley, San Bernardino County	A 110-square-mile basin with internal drainage. Younger alluvium.	525	300	20–220	830,000	Un
7-12	Warren Valley, San Bernardino County	A 20-square-mile basin drained by unnamed streams. Younger alluvium.	550	290	20–220	180,000	Un
7-13	Deadman Valley, San Bernardino County	A 160-square-mile basin with internal drainage. Younger alluvium.	Unknown	Unknown	20–220	1,270,000	Un
7-14	Lavic Valley, San Bernardino County	A 40-square-mile basin with internal drainage. Younger alluvium.	140	80	20–220	270,000	Un
7-15	Bessemer Valley, San Bernardino County	A 85-square-mile basin with internal drainage. Younger alluvium.	Unknown	Unknown	20–300	740,000	Un
7-16	Ames Valley, San Bernardino County	A 150-square-mile basin with internal drainage. Younger alluvium.	Unknown	Unknown	20–220	1,200,000	Un
7-17	Means Valley, San Bernardino County	A 25-square-mile basin with internal drainage. Younger alluvium.	Unknown	Unknown	20–300	260,000	Un
7-18	Johnson Valley, San Bernardino County	A 150-square-mile basin with internal drainage. Younger alluvium.	Unknown	Unknown	20–300	1,300,000	Un
7-19	Lucerne Valley, San Bernardino County	A 260-square-mile basin with internal drainage. Younger alluvium.	2,500	700	1961 water levels to base of water-bearing unit.	4,736,000	2,5 gr su 19 w le
7-20	Morongo Valley, San Bernardino County	A 14-square-mile basin drained by Big Morongo Creek. Younger alluvium.	600	90	20–220	100,000	Un
7-21	Coachella Valley, Imperial and Riverside Counties	A 690-square-mile basin drained by the Whitewater River. Younger and older alluvium.	3000+	300	100–1000	39,000,000	3,6
7-22	West Salton Sea Basin, Imperial County	A 190-square-mile basin adjoining the west shore of Salton Sea. Younger and older alluvium.	540	400	Unknown	Unknown	Un

GROUND WATER RESOURCES DESERT AREA—Continued

Development	Degree of knowledge	Problems
Limited to moderate for domestic use. Natural recharge estimated at about 300 AFY. 1952 extractions 760 AF. A potential for limited to moderate additional development.	Superficial to limited for geology and hydrology and limited for water quality. References: DWR 40, 75; USBR 14; USGS 44, 110	Locally fluoride high for domestic use.
Moderate for domestic use. Natural recharge estimated at about 1100 AFY. 1969 extractions about 450 AF. A potential for moderate additional development.	Limited for geology, hydrology, and water quality. References: DWR 40, 75; USBR 14; USGS 72	Failing septic tanks.
Limited for irrigation and domestic use. Natural recharge estimated at about 500 AFY. 1969 extractions about 1500 AF. A potential for limited additional development.	Limited for geology, hydrology, and water quality. References: DWR 40, 75; USBR 14; USGS 72	Failing septic tanks.
Limited for domestic use. Natural recharge estimated at about 400 AFY. Water exported to Twentynine Palms Marine Corps Base. A potential for moderate additional development.	Limited for geology, hydrology and water quality in west and superficial in east. References: DWR 40, 75; USBR 14; USGS 72	Poor quality vicinity of Deadman dry lake.
Limited for domestic use. Natural recharge estimated at about 300 AFY. A potential for moderate additional development.	Superficial for geology, hydrology, and water quality. References: DWR 40, 87	Locally TDS high for domestic use.
No development. Natural recharge estimated at about 300 AFY. A potential for limited to moderate additional development.	Superficial for geology, hydrology, and water quality. References: DWR 40; USBR 14; USGS 109	None known.
Limited for domestic use. Natural recharge estimated at about 700 AFY. A potential for moderate additional development.	Superficial for geology and hydrology. Limited for water quality. References: DWR 40, 75; USBR 14; USGS 72	Locally unsuitable for domestic and irrigation use. High TDS, fluoride, and chloride.
Limited for livestock use. Natural recharge estimated at about 100 AFY. A potential for limited additional development.	Limited for geology and hydrology. Superficial for water quality. References: DWR 40, 75; USBR 14; USGS 72, 109	None known.
Limited for livestock, irrigation, and domestic use. Natural recharge estimated at about 2300 AFY. 1952 extractions about 62 AF. A potential for limited to moderate additional development.	Superficial for geology and hydrology. Limited for water quality. References: DWR 40; USBR 14; USGS 72, 109	Sulfate high for domestic use.
Moderate for irrigation, domestic, and livestock use. Recharge under 1960–61 cultural conditions 5700 AFY, 1960–61 extractions 12,000 AF. A potential for limited to moderate additional development.	Limited for geology, hydrology, and water quality. References: DWR 40, 71; USGS 5, 109	Locally TDS, nitrate, chloride, sulfate, and fluoride high for domestic use; TDS and boron high for irrigation use. Overdraft.
Moderate for domestic use. Natural recharge estimated at about 800 AFY. 1952 extractions about 230 AF. A potential for limited additional development.	Superficial for geology and hydrology. Limited for water quality. References: DWR 40; USBR 14; USGS 5, 109	None known.
Moderate to high for municipal and irrigation use. Limited for domestic use. Natural recharge estimated at about 80,000 AFY. 1952 extractions about 177,000 AF. A potential for limited additional development.	Intensive for geology, hydrology and water quality in center, moderate in ends. References: DWR 40, 115, 180; USGS 15, 32, 89, 120, 121	Locally fluoride, sulfate, and TDS high for domestic use; boron high for irrigation. Poor quality semi-perched water. Overdraft.
Limited for domestic use. A potential for limited additional development.	Superficial for geology and hydrology. Limited for water quality. References: DWR 40	Locally quality marginal to unacceptable for irrigation use and unacceptable for domestic use.

Basin number	Basin name, county	Basin description: size, major stream, water bearing material	Well yields in gpm		Depth zone in feet	Storage capacity in acre-feet	Usable capacity in acre-feet
			Max.	Aver.			
7-23	Clark Valley, San Diego County	A 40-square-mile basin with internal drainage under low surface water flow. Younger and older alluvium.	35	20	0–200	450,000	300,000
7-24	Borrego Valley, San Diego County	A 110-square-mile basin drained by Coyote Creek. Younger and older alluvium.	3,000	900	0–200	1,300,000	1,000,000
7-25	Ocotillo Valley, Imperial and San Diego Counties	A 410-square-mile basin drained by San Felipe Creek. Younger and older alluvium.	1,800	550	0–200	5,800,000	1,900,000
7-26	Terwilliger Valley, Riverside County	A 10-square-mile basin drained by Coyote Creek. Older alluvium.	100	Unknown	0–200	Unknown	Unknown
7-27	San Felipe Valley, San Diego County	A 40-square-mile basin drained by San Felipe Creek. Younger alluvium.	500	30	0–200	Unknown	Unknown
7-28	Vallecito-Carrizo Valley, Imperial and San Diego Counties	A 200-square-mile basin drained by Vallecito and Carrizo Creeks. Younger and older alluvium.	2,500	260	0–200	2,500,000	Unknown
7-29	Coyote Wells Valley, Imperial and San Diego Counties	A 100-square-mile basin drained by Palm Canyon Wash. Younger and older alluvium.	Unknown	Unknown	100–300	1,700,000	Unknown
7-30	Imperial Valley, Imperial County	A 1,870-square-mile basin drained to the Salton Sea via the New and Alamo Rivers. Younger and older alluvium.	1,000	Unknown	100–300	14,000,000	Unknown
7-31	Orocopia Valley, Riverside County	A 140-square-mile basin drained by Box Canyon Wash. Younger and older alluvium.	210	165	200–400	1,500,000	Unknown
7-32	Chocolate Valley, Riverside County	A 120-square-mile basin drained by Salt Creek. Younger and older alluvium.	Unknown	Unknown	20–220	1,000,000	Unknown
7-33	East Salton Sea Basin, Imperial and Riverside Counties	A 150-square-mile basin drained by Salt Creek. Younger and older alluvium.	Unknown	Unknown	0–200	360,000	Unknown
7-34	Amos Valley, Imperial County	A 220-square-mile basin drained by unnamed streams. Younger alluvium.	100	50	0–200	2,900,000	Unknown
7-35	Ogilby Valley, Imperial County	A 220-square-mile basin drained by unnamed streams. Younger alluvium.	100	50	0–220	2,900,000	Unknown

GROUND WATER RESOURCES
DESERT
AREA—Continued

Development	Degree of knowledge	Problems
Limited for domestic use. Natural recharge estimated at about 1200 AFY. A potential for limited to moderate additional development.	Superficial for geology and hydrology. Limited for water quality. References: DWR 40, 88; USBR 17	Locally unsuitable for domestic and irrigation use. High fluoride, TDS, and percent sodium.
Moderate for irrigation and domestic use. Natural recharge estimated at about 3200 AFY. 1952 extractions about 10,400 AF. A potential for limited to moderate additional development.	Superficial for geology. Limited for hydrology and water quality. References: DWR 40, 88; USBR 17	Locally magnesium, nitrate, fluoride, sulfate, chloride, and TDS high for domestic use; percent sodium, TDS and chloride high for irrigation use.
Limited for irrigation and domestic use. Natural recharge estimated at about 1100 AFY. 1952 extractions about 3 AF. A potential for limited additional development.	Superficial for geology and hydrology. Limited for water quality. References: DWR 40, 88; USBR 17	Locally chloride, fluoride, sulfate, and TDS high for domestic use; percent sodium, TDS and chloride high for irrigation use.
Limited for irrigation and domestic use. Natural recharge estimated at about 400 AFY. 1952 extractions about 1900 AF. A potential for limited additional development.	Superficial for geology, hydrology, and water quality. References: DWR 40; DMG 6	Locally quality unsuitable for domestic and irrigation use.
Limited for livestock and domestic use. 1952 extractions about 38 AF. A potential for limited additional development.	Superficial for geology and hydrology. Limited for water quality. References: DWR 40, 88	Locally chloride, sulfate and TDS high for domestic use; chloride and TDS high for irrigation use.
Limited for domestic and livestock use. A potential for moderate to high additional development.	Superficial for geology and hydrology. Limited for water quality. References: DWR 40, 88	Locally, magnesium, sulfate, chloride, fluoride, and TDS high for domestic use; percent sodium high for irrigation use.
Limited for domestic use. Natural recharge estimated at about 300 AFY. 1952 extractions about 1 AF. A potential for moderate to high additional development.	Limited for geology, hydrology and water quality. References: DWR 40, 192	Locally poor quality for domestic and irrigation use.
Limited for livestock, domestic and irrigation use. Natural recharge estimated at about 3300 AFY. 1952 extractions about 300 AF. A potential for moderate additional development.	Limited for geology, hydrology, and water quality. References: DWR 40, 135; USGS 35	Large areas of poor quality water unsuited for domestic and irrigation use. Failing septic tanks near Brawley.
Limited for domestic and irrigation use. Natural recharge estimated at about 500 AFY. A potential for moderate additional development.	Superficial for geology and hydrology. Limited for water quality. References: DWR 40; DMG 4	Locally fluoride and TDS high for domestic use.
No development. Natural recharge estimated at about 200 AFY. A potential for moderate additional development.	Superficial for geology and hydrology. Limited for water quality. References: DWR 40; DMG 4	Locally poor quality for domestic and irrigation use.
Limited for domestic use. Natural recharge estimated at about 200 AFY. 1952 extractions about 6 AF. A potential for limited additional development.	Superficial for geology and hydrology. Limited for water quality. References: DWR 40; DMG 4	Locally quality marginal to unacceptable for irrigation use and unacceptable for domestic use.
Limited for domestic and industrial use. Natural recharge estimated at about 250 AFY. A potential for moderate additional development.	Superficial for geology and hydrology. Limited for water quality. References: DWR 40; DMG 4, 9	Locally quality poor for domestic use.
Limited for domestic and industrial use. Natural recharge estimated at about 250 AFY. 1952 extractions about 9 AF. A potential for moderate additional development.	Superficial for geology and hydrology. Limited for water quality. References: DWR 40; DMG 9	Locally quality poor for domestic use.

Basin number	Basin name, county	Basin description: size, major stream, water bearing material	Well yields in gpm		Depth zone in feet	Storage capacity in acre-feet	Usable capacity in acre-feet
			Max.	Aver.			
7-36	Yuma Valley, Imperial County	A 170-square-mile basin with drainage to the Colorado River. Younger and older alluvium.	100	40	0–200	4,600,000	Unknown
7-37	Arroyo Seco Valley, Imperial and Riverside Counties	A 430-square-mile basin drained by Arroyo Seco Wash tributary to the Colorado River. Younger and older alluvium.	Unknown	Unknown	0–200	7,000,000	Unknown
7-38	Palo Verde Valley, Imperial and Riverside Counties	A 200-square-mile basin with drainage to the Colorado River. Younger alluvium.	2,180	670	0–300	4,960,000	Unknown
7-39	Palo Verde Mesa, Imperial and Riverside Counties	A 280-square-mile mesa drained by unnamed streams. Younger alluvium.	2,750	1,650	0–300	6,840,000	Unknown
7-40	Quien Sabe Point Valley, Riverside County	A 40-square-mile basin drained by McCoy Wash a tributary to the Colorado River. Younger and older alluvium.	25	Unknown	0–200	230,000	Unknown
7-41	Calzona Valley, Riverside and San Bernardino Counties	A 150-square-mile basin drained by Vidal Wash. Younger alluvium.	2,340	500	100–500	1,500,000	Unknown
7-42	Vidal Valley, Riverside and San Bernardino Counties	A 160-square-mile basin drained by Vidal Wash a tributary to the Colorado River. Younger alluvium.	1,800	675	100–500	1,600,000	Unknown
7-43	Chemehuevi Valley, San Bernardino County	A 440-square-mile basin drained by Chemehuevi Wash, a tributary to the Colorado River. Younger alluvium.	Unknown	Unknown	0–200	4,700,000	Unknown
7-44	Needles Valley, San Bernardino County	A 140-square-mile basin drained by Piute Wash, a tributary to the Colorado River. Younger alluvium.	1,500	980	0–200	1,100,000	Unknown
7-45	Piute Valley, San Bernardino County	A 270-square-mile basin drained by Piute Wash. Younger alluvium.	360	200	300–500	2,400,000	Unknown
7-47	Jacumba Valley, San Diego County	A 10-square-mile basin bordering the Republic of Mexico. Younger alluvium.	900	Unknown	Unknown	Unknown	Unknown

GROUND WATER RESOURCES
DESERT
AREA—Continued

Development	Degree of knowledge	Problems
Moderate for domestic and irrigation use. Natural recharge estimated at about 400 AFY. A potential for moderate additional development.	Limited for geology, hydrology and water quality in east and superficial in west. References: DWR 40; DMG 9; USGS 95	Locally magnesium, sulfate, chloride, manganese and TDS high for domestic use; chloride, TDS and percent sodium high for irrigation use. Failing septic tank and leach field systems. Overdraft projected for 1975 because of export of municipal waste water.
Limited for domestic use. Natural recharge estimated at about 1500 AFY. A potential for moderate to high additional development.	Superficial for geology and hydrology. Limited for water quality. References: DWR 40; DMG 4	Locally manganese, chloride, and TDS high for domestic use; TDS and percent sodium high for irrigation use.
Moderate for domestic and irrigation use. Natural recharge estimated at about 500 AFY. A potential for limited additional development.	Moderate for geology and limited for hydrology and water quality. References: DWR 40; USGS 79, 80	Locally fluoride, chloride, TDS and sulfate high for domestic use; chloride and TDS high for irrigation use. Failing septic tank and leach field systems.
Limited for domestic and irrigation use. Natural recharge estimated at about 800 AFY. A potential for moderate additional development.	Moderate to limited for geology, hydrology and water quality in the east, superficial in the west. References: DWR 40; USGS 79, 80	Locally arsenic, selenium, fluoride, chloride, sulfate, and TDS high for domestic use; chloride, boron, and TDS high for irrigation use. Overdraft.
Limited for domestic use. Natural recharge estimated at about 300 AFY. A potential for limited additional development.	Limited for geology, hydrology, and water quality. References: DWR 40; USGS 79, 80	Locally sulfate, chloride, fluoride, and TDS high for domestic use; chloride and TDS high for irrigation use.
Limited for domestic use. Natural recharge estimated at about 400 AFY. A potential for moderate additional development.	Limited for geology, hydrology, and water quality. References: DWR 40; USGS 79, 80	Locally sulfate, chloride, fluoride, and TDS high for domestic use; chloride high for irrigation use.
Limited for domestic and irrigation use. Natural recharge estimated at about 350 AFY. A potential for moderate additional development.	Superficial for geology, and hydrology. Limited for water quality. References: DWR 40, 81	Locally fluoride, sulfate, chloride, and TDS high for domestic use; chloride and percent sodium high for irrigation use.
Limited for domestic use. Natural recharge estimated at about 2300 AFY. A potential for moderate to high additional development.	Limited for geology, hydrology and water quality in east and superficial in west. References: DWR 40; USGS 81	Locally sulfate, chloride, fluoride, and TDS high for domestic use; percent sodium high for irrigation use.
Moderate for irrigation and municipal use and limited for domestic use. Natural recharge estimated at about 1000 AFY. A potential for moderate additional development.	Limited for geology, hydrology and water quality. References: DWR 40; USGS 66, 67, 81	Locally sulfate, chloride, fluoride and TDS high for domestic use; chloride, TDS and percent sodium high for irrigation use. Overdraft.
Limited for domestic use. Natural recharge estimated at about 1200 AFY. A potential for moderate additional development.	Limited for geology, hydrology, and water quality. References: DWR 40; Misc. 11	Locally sulfate and fluoride high for domestic use; percent sodium high for irrigation use.
Limited for domestic and irrigation use. Natural recharge estimated at about 1300 AFY. A potential for limited additional development.	Superficial for geology and hydrology. Limited for water quality. References: DWR 42; DMG 9	Locally sulfate, fluoride, and TDS high for domestic use.

County Listing of Ground Water Basins

County Listing of Ground Water Basins—Continued

Ground Water Basin	Number
Race Track Valley	6-62
Hidden Valley	6-63
Marble Canyon Area	6-64
Cottonwood Spring Area	6-65
Lee Flat	6-66
Santa Rosa Flat	6-68
Cactus Flat	6-70
Coles Flat	6-72
Wild Horse Mesa Area	6-73
Harrisburg Flats	6-74
Wildrose Canyon	6-75
California Valley	6-79
Middle Park Canyon Valley	6-80
Butte Valley	6-81
Spring Canyon Valley	6-82
Furnace Creek Area	6-83
Greenwater Valley	6-84
Gold Valley	6-85
Rhodes Hill Area	6-86

KERN COUNTY

Ground Water Basin	Number
Cuyama Valley	3-13
San Joaquin Valley	5-22
Kern River Valley	5-25
Walker Basin Creek Valley	5-26
Cummings Valley	5-27
Tehachapi Valley West	5-28
Castac Lake Valley	5-29
Inns Valley	5-79
Brite Valley	5-80
Bear Valley	5-81
Cuddy Canyon Valley	5-82
Cuddy Ranch Area	5-83
Cuddy Valley	5-84
Mill Potrera Area	5-85
Antelope Valley	6-44
Tehachapi Valley East	6-45
Fremont Valley	6-46
Harper Valley	6-47
Searles Valley	6-52
Indian Wells Valley	6-54
Kelso Lander Valley	6-69
Butterbread Canyon Valley	6-87

KINGS COUNTY

Ground Water Basin	Number
San Joaquin Valley	5-22

LAKE COUNTY

Ground Water Basin	Number
Gravelly Valley	1-48
Upper Lake Valley	5-13
Scott Valley	5-14
Kelseyville Valley (Big Valley)	5-15
High Valley	5-16
Burns Valley	5-17
Coyote Valley	5-18
Collayomi Valley	5-19
Lower Lake Valley	5-30
Long Valley	5-31
Little Indian Valley	5-65
Clear Lake Cache Formation Highlands	5-66
Clear Lake Pleistocene Volcanics	5-67
Pope Valley	5-68

LASSEN COUNTY

Ground Water Basin	Number
Big Valley	5-4
Fall River Valley	5-5
Mountain Meadows Valley	5-8
Modoc Plateau Recent Volcanic Areas	5-32
Modoc Plateau Pleistocene Volcanic Areas	5-33
Hot Spring Valley	5-40
Long Valley	5-44
Butte Creek Valley	5-51
Gray Valley	5-52
Dixie Valley	5-53
Ash Valley	5-54
Surprise Valley	6-1
Madeline Plains	6-2
Willow Creek Valley	6-3
Honey Lake Valley	6-4
Pine Creek Valley	6-92
Harvey Valley	6-93
Grasshopper Valley	6-94
Dry Valley	6-95
Eagle Lake Area	6-96
Horse Lake Valley	6-97
Tuledad Canyon Area	6-98
Painters Flat	6-99
Secret Valley	6-100
Bull Flat	6-101
Modoc Plateau Recent Volcanic Areas	6-102
Modoc Plateau Pleistocene Volcanic Areas	6-103
Long Valley	6-104

LOS ANGELES COUNTY

Ground Water Basin	Number
Santa Clara River Valley—Eastern Basin	4-4.07
Acton Valley	4-5
Coastal Plain—Los Angeles County	4-11
San Fernando Valley	4-12
San Gabriel Valley	4-13
Upper Santa Ana Valley	4-14
Hungry Valley	4-18
Russell Valley	4-20
Conejo-Tierra Rejada Volcanic Areas	4-21
Malibu Valley	4-22
Antelope Valley	6-44

MADERA COUNTY

Ground Water Basin	Number
San Joaquin Valley	5-22

MARIN COUNTY

Ground Water Basin	Number
Petaluma Valley	2-1
Sebastopol Merced Formation Highlands	2-25

County Listing of Ground Water Basins—Continued

Ground Water Basin	*Number*
Sand Point Area	2-27
Ross Valley	2-28
San Rafael Valley	2-29
Novato Valley	2-30

MARIPOSA COUNTY

Yosemite Valley	5-69

MENDOCINO COUNTY

Round Valley	1-11
Laytonville Valley	1-12
Little Lake Valley	1-13
Anderson Valley	1-19
Garcia River Valley	1-20
Fort Bragg Terrace Area	1-21
Cottoneva Creek Valley	1-37
Lower Laytonville Valley	1-38
Branscomb Town Area	1-39
Ten Mile River Valley	1-40
Little Valley	1-41
Sherwood Valley	1-42
Williams Valley	1-43
Eden Valley	1-44
Big River Valley	1-45
Navarro River Valley	1-46
Gualala River Valley	1-47
McDowell Valley	2-12
Potter Valley (Old No. 1-14)	2-14
Ukiah Valley (Old No. 1-15)	2-15
Sanel Valley (Old No. 1-16)	2-16

MERCED COUNTY

San Joaquin Valley	5-22
Los Banos Creek Valley	5-70

MODOC COUNTY

Klamath River Valley	1-2
Fairchild Swamp Valley	1-22
Modoc Plateau Recent Volcanic Areas	1-23
Modoc Plateau Pleistocene Volcanic Areas	1-24
Goose Lake Valley	5-1
Alturas Basin	5-2
Alturas Basin-South Fork Pit River and Alturas Area	5-2.01
Alturas Basin-Warm Springs Valley	5-2.02
Jess Valley	5-3
Big Valley	5-4
Modoc Plateau Recent Volcanic Areas	5-32
Modoc Plateau Pleistocene Volcanic Areas	5-33
Round Valley	5-36
Fandango Valley	5-39
Hot Spring Valley	5-40
Egg Lake Valley	5-41
Bucher Swamp Valley	5-42
Rocky Prairie Valley	5-43

Ground Water Basin	*Number*
Long Valley	5-44
Surprise Valley	6-1
Cow Head Lake Valley	6-91

MONO COUNTY

Antelope Valley (Topaz Valley)	6-7
Bridgeport Valley	6-8
Mono Valley	6-9
Adobe Lake Valley	6-10
Long Valley	6-11
Fish Lake Valley	6-14
Granite Mountain Area	6-59
Fish Slough Valley	6-60
Slinkard Valley	6-105
Little Antelope Valley	6-106
Sweetwater Flat	6-107

MONTEREY COUNTY

Pajaro Valley	3-2
Salinas Valley	3-4
Paso Robles Basin	3-4.06
Seaside Area	3-4.08
Langley Area	3-4.09
Corral de Tierra Area	3-4.10
Cholame Valley	3-5
Lockwood Valley	3-6
Carmel Valley	3-7

NAPA COUNTY

Napa-Sonoma Valley	2-2
Napa Valley	2-2.01
Berryessa Valley	5-20

NEVADA COUNTY

Martis Valley (Truckee Valley)	6-67

ORANGE COUNTY

Coastal Plain—Orange County	8-1
San Juan Valley	9-1

PLACER COUNTY

Sacramento Valley	5-21
Tahoe Valley	6-5
Tahoe Valley—North	6-5.02

PLUMAS COUNTY

Lake Almanor Valley	5-7
Indian Valley	5-9
American Valley	5-10
Mohawk Valley	5-11
Sierra Valley	5-12
Modoc Plateau Pleistocene Volcanic Areas	5-33
Sacramento Valley Eastside Tuscan Formation Highlands	5-55
Yellow Creek Valley	5-56
Last Chance Creek Valley	5-57

County Listing of Ground Water Basins—Continued

County Listing of Ground Water Basins—Continued

Ground Water Basin	Number
Ames Valley	7-16
Means Valley	7-17
Johnson Valley	7-18
Lucerne Valley	7-19
Morongo Valley	7-20
Calzona Valley	7-41
Vidal Valley	7-42
Chemehuevi Valley	7-43
Needles Valley	7-44
Piute Valley	7-45
Helendale Fault Valley	7-48
Pipes Canyon Fault Valley	7-49
Iron Ridge Area	7-50
Lost Horse Valley	7-51
Upper Santa Ana Valley	8-2
Big Meadows Valley	8-7
Seven Oaks Valley	8-8
Bear Valley	8-9
SAN DIEGO COUNTY	
Clark Valley	7-23
Borrego Valley	7-24
Ocotillo Valley	7-25
San Felipe Valley	7-27
Vallecito-Carrizo Valley	7-28
Coyote Wells Valley	7-29
Canebrake Valley	7-46
Jacumba Valley	7-47
Collins Valley	7-55
Yaqui Well Area	7-56
Pinyon Wash Area	7-57
Whale Peak Area	7-58
Mason Valley	7-59
Jacumba Valley-East	7-60
San Mateo Valley	9-2
San Onofre Valley	9-3
Santa Margarita Valley	9-4
San Luis Rey Valley	9-7
Warner Valley	9-8
Escondido Valley	9-9
San Pasqual Valley	9-10
Santa Maria Valley	9-11
San Dieguito Valley	9-12
Poway Valley	9-13
Mission Valley	9-14
San Diego River Valley	9-15
El Cajon Valley	9-16
Sweetwater Valley	9-17
Otay Valley	9-18
Tia Juana Basin	9-19
Jamul Valley	9-20
Las Pulgas Valley	9-21
Batiquitos Lagoon Valley	9-22
San Elijo Valley	9-23
Pamo Valley	9-24

Ground Water Basin	Number
Ranchito Town Area	9-25
Pine Valley	9-26
Cottonwood Valley	9-27
Campo Valley	9-28
Potrero Valley	9-29
Tecate Valley	9-30
SAN FRANCISCO COUNTY	
Visitation Valley	2-32
Islais Valley	2-33
San Francisco Sand Dune Area	2-34
Merced Valley	2-35
SAN JOAQUIN COUNTY	
San Joaquin Valley	5-22
SAN LUIS OBISPO COUNTY	
Paso Robles Basin	3-4.06
Cholame Valley	3-5
Los Osos Valley	3-8
San Luis Obispo Valley	3-9
Pismo Creek Valley	3-10
Arroyo Grande Valley-Nipomo Mesa Area	3-11
Santa Maria River Valley	3-12
Cuyama Valley	3-13
Carrizo Plain	3-19
San Carpoforo Valley	3-33
Arroyo de la Cruz	3-34
San Simeon Valley	3-35
Santa Rosa Valley	3-36
Villa Valley	3-37
Cayucos Valley	3-38
Old Valley	3-39
Toro Valley	3-40
Morro Valley	3-41
Chorro Valley	3-42
Rinconada Valley	3-43
Pozo Valley	3-44
Huasna Valley	3-45
Rafael Valley	3-46
Big Spring Area	3-47
SAN MATEO COUNTY	
Santa Clara Valley	2-9
Half Moon Bay Terrace	2-22
San Gregorio Valley	2-24
Pescadero Valley	2-26
Visitation Valley	2-32
Merced Valley	2-35
San Pedro Valley	2-36
Ano Nuevo Area	3-20
SANTA BARBARA COUNTY	
Santa Maria River Valley	3-12
Cuyama Valley	3-13
San Antonio Creek Valley	3-14

County Listing of Ground Water Basins—Continued

Ground Water Basin	Number
Santa Ynez River Valley	3-15
Goleta Basin	3-16
Santa Barbara Basin	3-17
Carpinteria Basin	3-18
Careaga Sand Highlands	3-48
Montecito Area	3-49

SANTA CLARA COUNTY

Santa Clara Valley	2-9
Santa Clara Valley—South Bay Area	2-9.02
Gilroy-Hollister Valley	3-3

SANTA CRUZ COUNTY

Soquel Valley	3-1
Pajaro Valley	3-2
Ano Nuevo Area	3-20
Santa Cruz Purisima Formation Highlands	3-21
West Santa Cruz Terrace	3-26
Scotts Valley	3-27

SHASTA COUNTY

Fall River Valley	5-5
Redding Basin	5-6
Modoc Plateau Recent Volcanic Areas	5-32
Modoc Plateau Pleistocene Volcanic Areas	5-33
Pondosa Town Area	5-38
Hot Spring Valley	5-40
Cayton Valley	5-45
Lake Britton Area	5-46
Goose Valley	5-47
Burney Creek Valley	5-48
Dry Burney Creek Valley	5-49
North Fork Battle Creek Valley	5-50

SIERRA COUNTY

Sierra Valley	5-12
Martis Valley (Truckee Valley)	6-67
Long Valley	6-104

SISKIYOU COUNTY

Klamath River Valley	1-2
Butte Valley	1-3
Shasta Valley	1-4
Scott River Valley	1-5
Happy Camp Town Area	1-15
Seiad Valley	1-16
Bray Town Area	1-17
Red Rock Valley	1-18
Modoc Plateau Recent Volcanic Areas	1-23
Modoc Plateau Pleistocene Volcanic Areas	1-24
Modoc Plateau Recent Volcanic Areas	5-32
Modoc Plateau Pleistocene Volcanic Areas	5-33
Mount Shasta Area	5-34
McCloud Area	5-35
Toad Well Area	5-37
Pondosa Town Area	5-38

SOLANO COUNTY

Napa-Sonoma Valley	2-2
Napa Valley	2-2.01
Suisun-Fairfield Valley	2-3
Sacramento Valley	5-21

SONOMA COUNTY

Anapolis Ohlson Ranch Formation Highlands	1-49
Petaluma Valley	2-1
Napa-Sonoma Valley	2-2
Sonoma Valley	2-2.02
Knights Valley (Old No. 1-22)	2-13
Alexander Valley (Old No. 1-17)	2-17
Alexander Valley-Alexander Area (Old No. 1-17.01)	2-17.01
Alexander Valley-Cloverdale Area (Old No. 1-17.02)	2-17.02
Santa Rosa Valley (Old No. 1-18)	2-18
Santa Rosa Valley-Santa Rosa Plain (Old No. 1-18.01)	2-18.01
Santa Rosa Valley-Healdsburg Area (Old No. 1-18.02)	2-18.02
Santa Rosa Valley-Rincon Valley (Old No. 1-18.03)	2-18.03
Kenwood Valley (Old No. 1-23)	2-19
Lower Russian River Valley (Old No. 1-98)	2-20
Bodega Bay Area	2-21
Napa-Sonoma Volcanics Highlands	2-23
Sebastopol Merced Formation Highlands	2-25

STANISLAUS COUNTY

San Joaquin Valley	5-22

SUTTER COUNTY

Sacramento Valley	5-21

TEHAMA COUNTY

Redding Basin	5-6
Sacramento Valley	5-21
Modoc Plateau Pleistocene Volcanic Areas	5-33
Sacramento Valley Eastside Tuscan Formation Highlands	5-55

TRINITY COUNTY

Hayfork Valley	1-6
Hyampon Valley	1-35
Hettenshaw Valley	1-36

TULARE COUNTY

San Joaquin Valley	5-22
Three Rivers Area	5-73
Springville Area	5-74
Templeton Mountain Area	5-75
Manache Meadows Area	5-76

County Listing of Ground Water Basins—Continued

Bibliographies

Two bibliographies follow. The first bibliography presents a selected list of references that are statewide in scope and also cover specialized topics. The second bibliography presents all of the references cited in the nine hydrologic study area inventories. The references are arranged numerically by agency. Abstracts of all Department of Water Resources Bulletins released since 1922 are available in the Department's Bulletin No. 170 Series.

All reports are available for inspection, loan, and/or purchase through the individual agencies. Many of the reports are available in public and university libraries. Reports of the U. S. Bureau of Reclamation, Mid-Pacific Regional Office are available for inspection only at their Geology Section Office, 2800 Cottage Way, Sacramento, California 95825.

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CHAPTER IV. GROUND WATER BASIN PROTECTION AND UTILIZATION

The use of ground water basins in California has developed several kinds of problems. Pump lifts varying from 500 to 1,000 feet in some areas have made water too expensive for most agricultural uses. In several basins, excessive pumping has permitted salt water, from natural sources beneath or beside the basins, to enter the basin and degrade a portion of the water. At times, disposal of wastes has added salts, disagreeable odors, or toxic materials to the ground water and impaired its usefulness. Extensive pumping of ground water with reduction in pressure has also caused deep lying clay beds to compact, resulting in actual sinking of the ground surface.

Excessive reliance on surface water supplies produces high ground water levels in some areas. This is a problem because pumping to keep water levels below root zones of crops in some of these basins results in waste when the drained water is not beneficially used in the area or downstream.

Solutions for many of these problems, as well as measures that have increased the usability of some basins, have been developed and implemented in some parts of the State.

Protection of Basins

The following problems and methods of solution apply to some of California's ground water basins. Frequently, the problem is recognized for a long while before any solution is implemented.

Excessive Pump Lifts

One of California's first ground water laws prohibited waste of water from artesian wells. Even with this regulation, it did not take long for the rate of use of water from the basin to exceed the amount available from flowing artesian wells. Introduction of pumps to increase the flows soon lowered the ground water level in the basins so that free flowing wells became a rarity. Further lowering of the water table required that wells be deepened or, in many cases, that shallow wells be replaced with deeper wells. Very few basins have achieved a balance between withdrawal of water and natural recharge. In most cases, some form of management had to be instituted or is now needed.

Salt Water Intrusion

Water in the seaward portion of basins bordered by the ocean, or by bays and channels containing brackish water, has often become unusable due to intrusion of sea water, as pumping lowered the ground water levels below sea level. The intrusion is sometimes in-

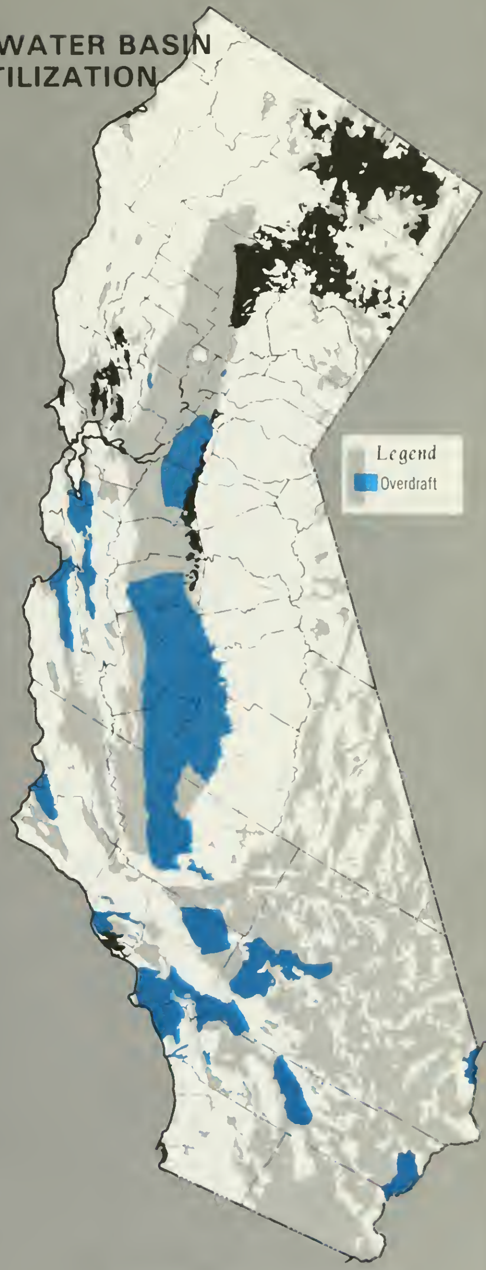


Figure 16. Basins with Overdraft

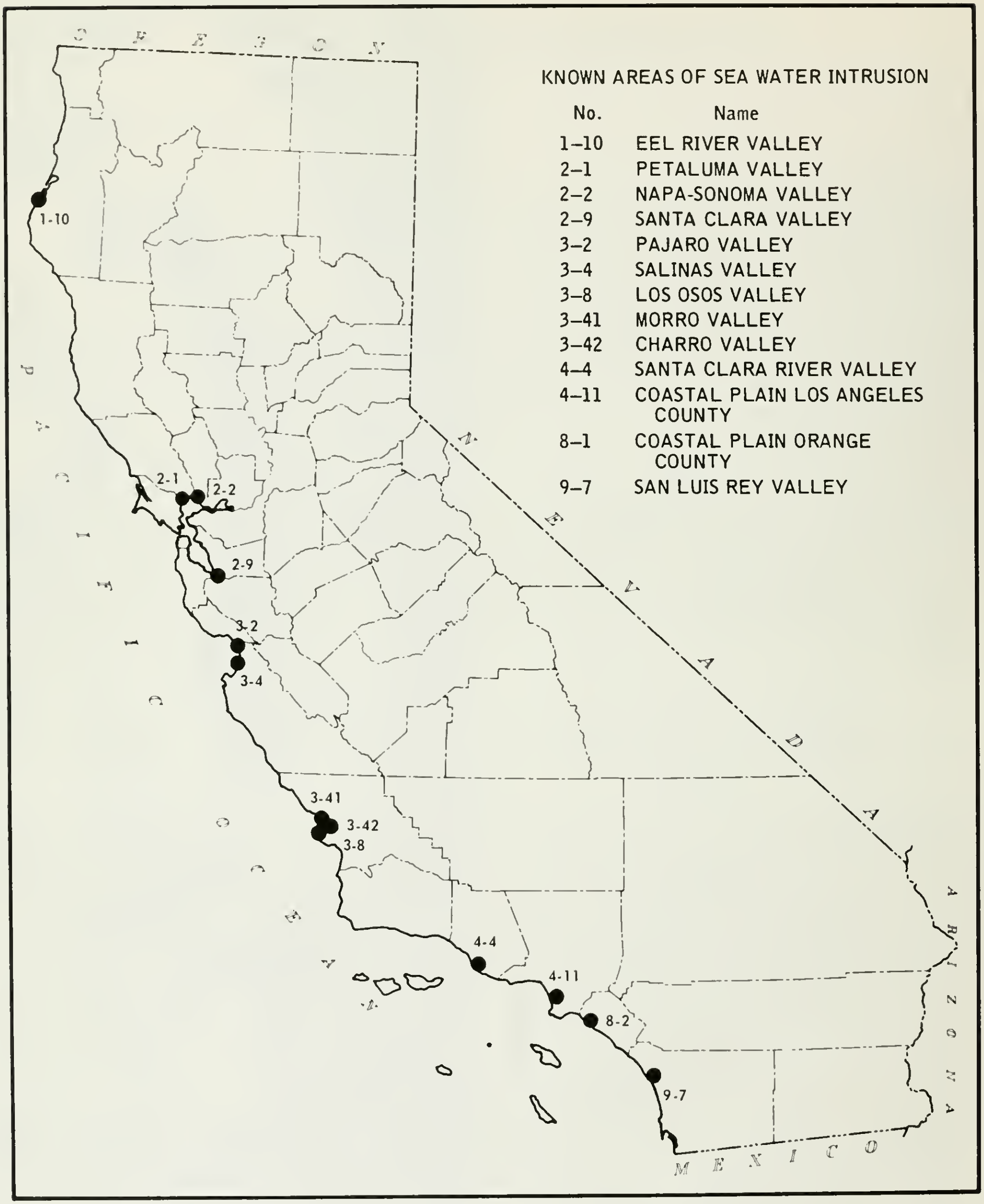


Figure 17. Sea Water Intrusion in Ground Water Basins

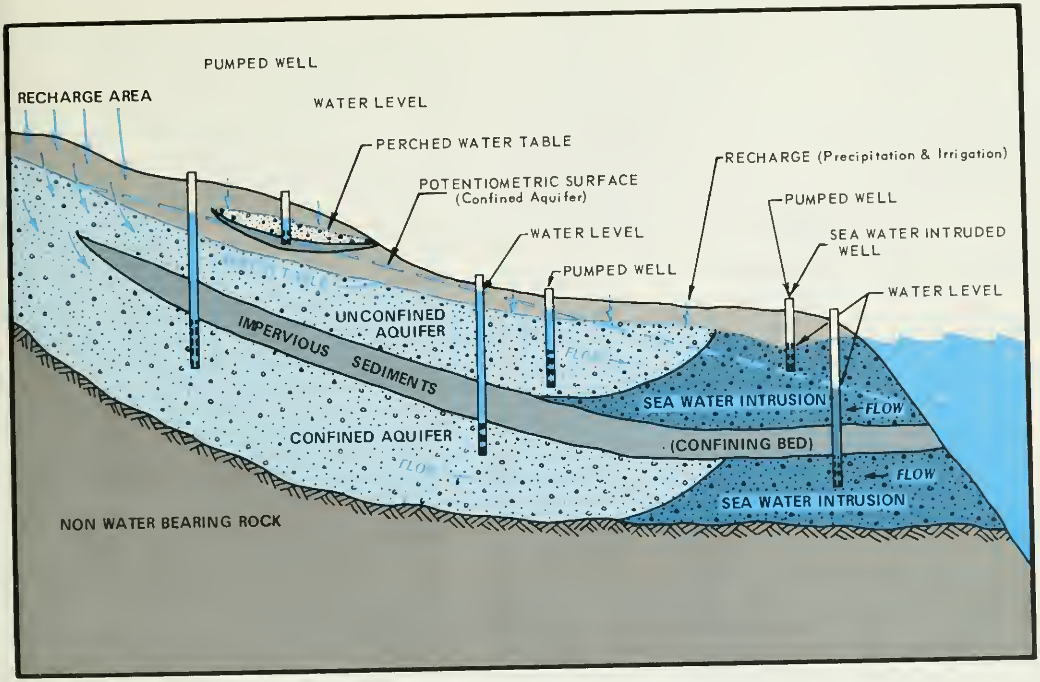
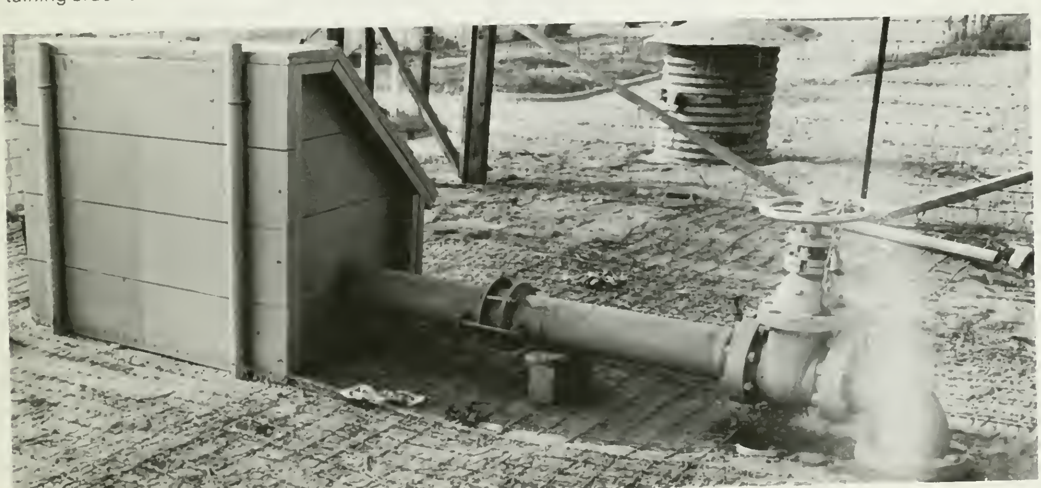


Figure 18. Sea Water Intruding a Coastal Basin

creased because of excavation of protecting fine grained soils. Many inland ground water basins are underlain, and occasionally flanked by, sediments containing brackish or saline water. In several cases, heavy pumping from the overlying fresh water has caused salt water to move upward and mingle with the fresh water, thus limiting the usefulness of the water from the basin.



Injection Well in Sea Water Barrier

Quality Degradation

Industrial processes and waste disposal have created many kinds of water quality problems, categorized generally under the heading of water quality degradation. Contributing factors include the disposal of brines from oil fields by percolation into ground water basins, the discharge of brines from water softener regeneration plants by means that allow wastes to enter ground water basins, and the leaching of soluble material from refuse dumps. In some instances, surface water has been permitted to flow through the refuse dumps, thus accelerating the leaching and percolation of undesirable material to the ground water.

Some of the causes of ground water degradation are obscure and take many years to be recognized. Waste disposal practices at the Rocky Mountain Arsenal northeast of Denver, Colorado, seriously damaged a ground water aquifer throughout an area of approximately 6½ square miles. Contaminants were chlorates and 2.4 D type compounds, both of which are effective herbicides. Both compounds were generated in waste disposal ponds by chemical reactions among other compounds discharged by chemical factories in the Arsenal. Travel of the water through the permeable alluvium in which the ponds were constructed was very slow. Crop damage was first reported eleven years after disposal of the wastes began at a location 3½ miles from the ponds.

Contaminated ground water within the affected area is toxic to agricultural crops and impotable for humans. Corrective measures have been taken to halt further contamination, but the area of toxicity is expanding owing to migration of the body of ground water already contaminated.

An unusual condition of quality degradation near Los Angeles resulted from leakage of gasoline from a buried pipeline. The degradation was first discovered in 1968, when Forest Lawn Memorial Park reported pumping gasoline from one of its irrigation wells. Results of a subsequent study estimated that approximately 160,000 square feet were underlain with 250,000 gallons of gasoline. During the next three years about 50,000 gallons of the gasoline were removed by pumping the wells.

Of concern at present is the uncertainty about the possible effects on human health of a variety of stable organic industrial wastes that find their way into sewage and industrial wastes that, in turn, enter ground water basins.

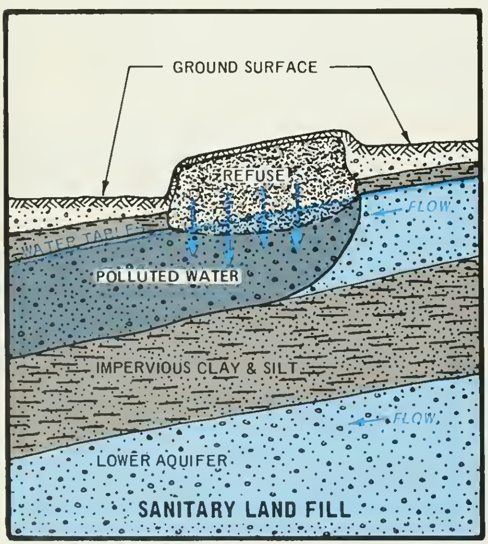


Figure 19. Dump Site in Ground Water Basin

Buildup of Salt in Ground Water

A problem rapidly gaining the degree of concern it merits is buildup of salt concentrations in some basins. The San Joaquin Valley from Fresno on south is especially subject to salt buildup, because there is little outflow of water from the Valley. Moreover, about 2 million tons of salt enter the Valley each year in imported water and in runoff from local watersheds. Use of water for both urban and agricultural purposes contributes to the salt buildup. As plants remove water from the soil, they leave behind nearly all the salt that was dissolved in the water.

High Water Tables

In some areas, surface water applied in excess of consumptive requirements of urban and agricultural uses has saturated the underlying soil all the way to the ground surface. This situation usually occurs where the price charged for the surface water is very low. The high water tables result in various problems, the specific form depending on the use of the land. Various buried or open ditch drain systems are used to lower the water table, especially when the water-bearing material near the surface is not sufficiently permeable to yield water to wells. The drains also prevent salt buildup in the soil, due to evapotranspiration by plants that use very large quantities of water.

In some basins, wells are used to lower the ground water level. This provides an opportunity for use of both surface water and ground water storage capacity. However, when the ground water is pumped at times when it cannot be used in the area or downstream, the water is wasted.

Land Subsidence

Extensive use of ground water basins has caused structural change in some basins, and has affected the quantity and quality of water. In many basins, lowering of water levels from one hundred to several hundred feet has allowed water to be squeezed from clay lenses; this causes the solid particles making up the clay to consolidate so that they occupy a smaller volume, and the clay lenses become thinner. In one area of the San Joaquin Valley, the land surface has lowered as much as 28 feet.

This type of subsidence has occurred most notably on both the western and southern portions of the San Joaquin Valley and to a lesser degree at San Jose in the Santa Clara Valley. It has required repair and remodeling of many forms of public and private facilities—particularly water facilities, which are very sensitive to changes in land elevation.

Water Well Standards

To aid in protecting California's ground waters, standards for the construction and destruction of wells have been developed. Besides extracting water from the ground, wells can also be a means for impairing the quality of ground water. This occurs when wells provide a physical connection between sources of pollution and usable water because of inadequate construction or improper disposition when their useful lives are over.

The solution is to use methods and materials that *are* adequate. To this end, the Department has issued statewide standards for well construction and destruction (Bulletin No. 74, "Water Well Standards: State of California" February 1968). In addition, studies applying these standards to specific ground water conditions have been made in ten areas. The California Regional Water Quality Control Boards and the Department of Health also have a role in adoption of the standards.

The task of establishing well standards falls to the counties and cities. As of mid-1975, 23 counties have enacted well ordinances and ten others, ordinances limited to specific kinds of wells. Of California's 411 cities, 110 enforce standards.

While urging adoption of ordinances, the Department is also striving to see that proper well construction practices are employed statewide and that abandoned wells are properly destroyed.

Management of Ground Water Resources

Many misconceptions and myths concerning ground water management still exist. Three common misconceptions are that (1) ground water levels must be maintained or raised, (2) ground water that is mined or overdrafted will destroy the usefulness of the ground water reservoir, and (3) ground water is different from any other resource and therefore must be managed differently.

Those misconceptions have often influenced ground water resources planning. In many cases, taking immediate steps to avoid declining water levels, to eliminate overdraft, and to forestall possible subsidence and water quality degradation, has become the objective of ground water basin management. Thus, many alternatives, such as controlled mining for a lim-

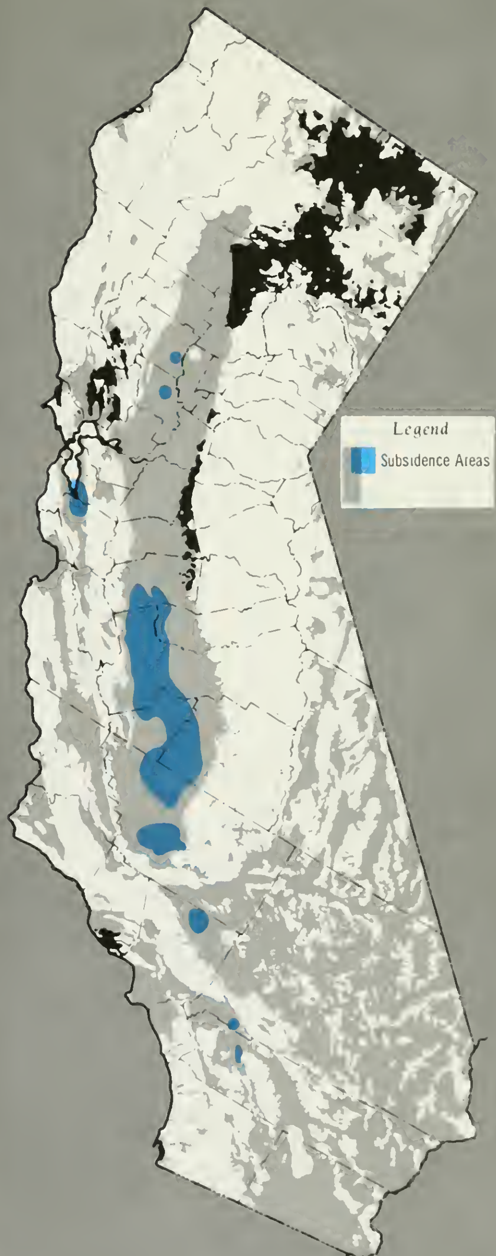


Figure 20. Land Subsidence Due to Ground Water Overdroft

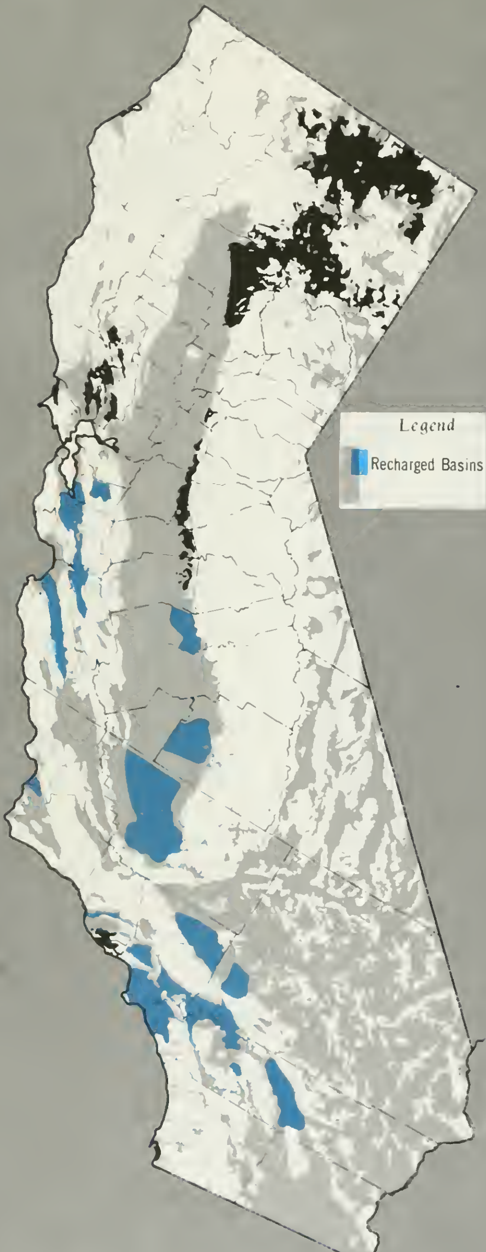


Figure 21. Basins with Artificial Recharge Projects

ited period and selective uses of ground water basins for salt sinks and other purposes, have not received consideration.

Recharge

Water users recognized long ago that if a constant supply of surface water could be provided to the more permeable recharge areas of basins, the yield of the basins could be increased. In some cases, surface supplies have been obtained by construction of dams and reservoirs to regulate streams solely for the purpose of releasing the water for ground water recharge. In other areas, most of the winter runoff stored in the reservoirs has been used for direct surface application during the summer months and the remaining portion has been used for ground water recharge.

In many cases, water has been imported in excess of the needs of a basin to replace water that was mined from the basin before the imported supply became available. In a few areas, where highly permeable recharge areas are either limited or unavailable, lands overlying the basin are irrigated during the nongrowing season in years of large runoff to recharge the ground water basin. Waste water has also been used in several recharge projects.

Control of Pumping

When all available recharge opportunities have been fully developed, pumping by all ground water users has been controlled in some basins, so that water is not taken from the basin to the point of depletion. This step has almost always been accompanied by importation of water for surface distribution.

Situations may arise in the future where it will be necessary to curtail the actual use of water rather than replace the cutback in ground water with an imported supply. However, if water is imported to offset an overdraft situation, any irrigation of new land, at the expense of not offsetting the overdraft, should be evaluated and specifically approved as part of the project.

Recharge Area and Recreation

Conjunctive Use with Surface Water

Conjunctive use involves the planned use of underground storage in coordination with surface water supplies to increase the yield of the total water resource. This can be accomplished by several methods or combinations of methods. All involve the operation of surface storage facilities—either locally or at some distance from the ground water basin—and the delivery of water to overlying lands where recharge can be accomplished by (1) extending flow in stream channels, (2) operation of spreading basins and surface irrigation conveyance facilities, and (3) percolation of excess applied surface irrigation supplies.

In a few basins, in addition to ground water, substantial surface supplies are available for use on the overlying irrigated lands. In such basins a conjunctive operation has evolved without any particular planning. The surface water is distributed to most of the lands to meet crop water requirements during years of normal or above normal runoff, and ground water is used to irrigate much of the land during years of low runoff. Yolo County, with a highly variable supply of surface water from Clear Lake, has been a notable example of this type of unplanned conjunctive operation. Planned conjunctive operation has also taken place in basins that have had to import surface water from some other watershed.

Maintenance of Water Quality

Where sea water intrusion has occurred, various kinds of barriers can be constructed to control the movement of water from the ocean into a ground water basin. Limiting pumping from a basin so that there is always a positive gradient toward the ocean is effective, but usually limits a basin's usefulness by requiring that it be nearly full at all times.

Another method is to inject surface water into the aquifers in a line of wells parallel to the coastline to create a ground water mound. Some of the injected water is lost as it flows toward the ocean to prevent salt water from moving inland, and some of the injected water flows inland and contributes to the supply in the basin.

A reverse process has also been used, in which a line of wells parallel to the coast has been pumped, resulting in movement of both fresh water and salt water to the wells. This limits the distance salt water will move into the basin but also results in loss of the fresh water that is mixed with the salt water withdrawn from the wells. Physical barriers have been considered for some shallow aquifers but only one small barrier has been installed in a ground water basin in California.

Where ground water basins are underlain by salt water, the only practical solution to resulting quality problems has been to limit the depth and spacing of wells and the amount of water withdrawn from the basin to avoid mixing of the two water bodies.

In a large enclosed ground water basin such as the Tulare Basin, where surface outflow occurs only in

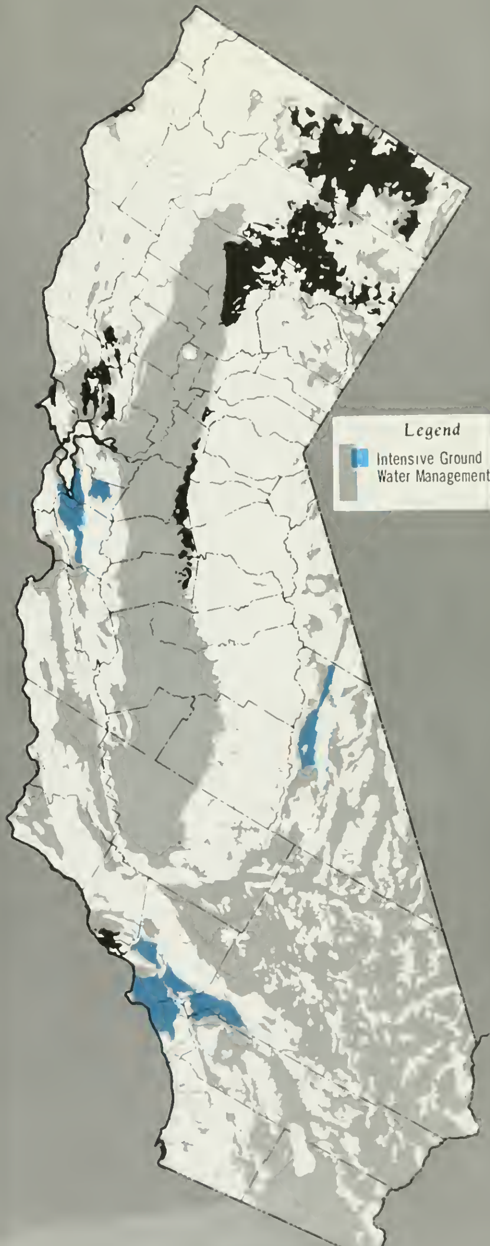
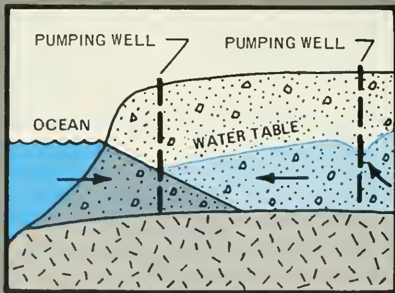
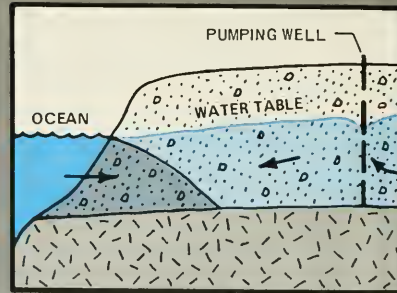


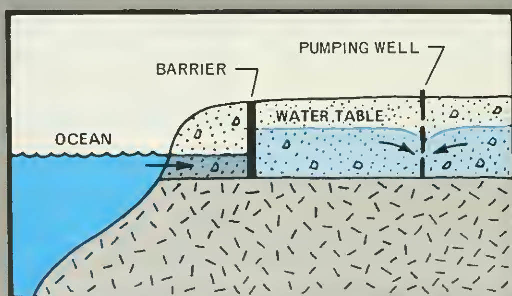
Figure 22. Basins Under Intensive Ground Water Management



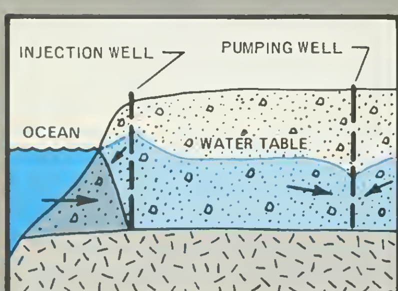
PUMPING TROUGH BARRIER



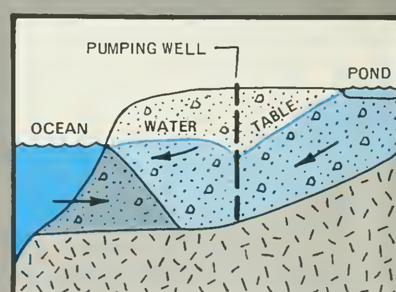
CONTROLLED PUMPING



MAN-MADE PHYSICAL BARRIER



INJECTION BARRIER



ARTIFICIAL - RECHARGE

Figure 23. Sea Water Intrusion Protective Measures

extremely wet years, a controlled degradation concept of management has been suggested as an interim means of controlling salinity in the basin. This concept envisions reduction of salt load reaching the underlying ground water basin when practicable and feasible. Suggested ways to implement this concept include: (1) review of fertilization and soil amendment practices, (2) study of methods to control leachate from newly developed lands, and (3) evaluation of recent information of the potential for salt storage through increased irrigation efficiency.

A large variety of measures have been taken to control disposal of man-made wastes, to correct problems resulting from polluted ground water and to prevent new problems from occurring. These measures are extremely important, because a basin that may be expected to be used for thousands of years can become unusable, perhaps permanently, within only a few years by deliberate or accidental pollution.

Figure 24. Sea Water Intrusion Barriers

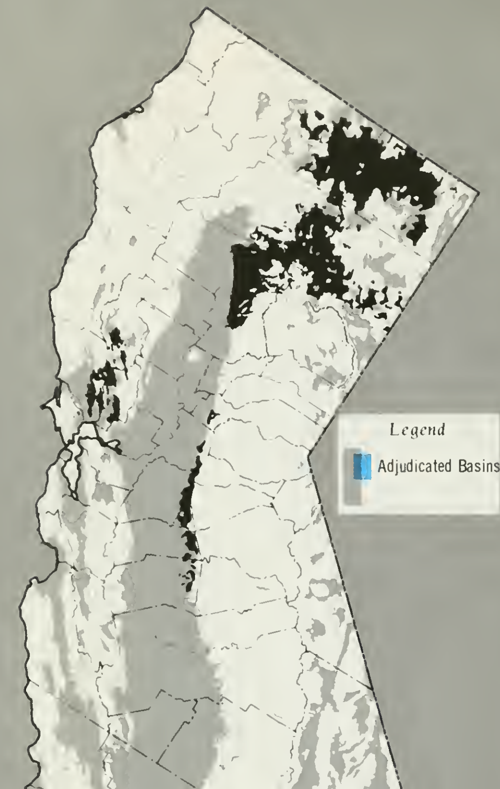


Figure 25. Adjudicated Ground Water Basins

Ground Water Law

Much of the law relating to the use of ground w
in California has been developed by the courts si
very few statutes affecting ground water rights h
been adopted by the California Legislature.[1]

Most of the ground water in California is "perc
ing water", waters trapped in aquifers of undergro
basins through which it slowly percolates. The cor
tive rights doctrine governs rights to percola
ground water. It is analogous to riparian rights. E
overlying landowner is entitled to make reason
beneficial use of ground water with a priority equ
all other overlying users. Water in excess of the ne
of the overlying owners can be pumped and used
nonoverlying lands on a first-in-time, first-in-right b
but such appropriative rights are extinguished in
absence of prescription when overlying users make
use of available supplies. When there is not suffic
water to meet the needs of the overlying owners,
courts have applied the principle of "correla
rights" to apportion such water among the overl
landowners.[2]

In several Southern California basins, where the
ter users had badly depleted the ground water by
time a court action was commenced, the courts h
developed a doctrine of "mutual prescription" u
which the water users are given a share of the "
yield" of the basin. In all of the earlier lawsuits
rights in ground water basins, commencing with
Raymond Basin of Southern California,[3] the wate
ers have entered into stipulated judgments which h
protected the established uses under the princip
"mutual prescription" by prorating the rights on
basis of the use of water during the five years imm
ately preceding the filing of the court actions. A
ception to these earlier "mutual prescription" j
ments is the recent *San Fernando* case decided by
California Supreme Court on May 12, 1975.[4]

Under the earlier "mutual prescription" stipul
judgments the total annual ground water produc
usually has been limited to the "safe yield" of the b
that is, the average annual amount of water w
naturally recharges the basin. The courts adopted
safe yield concept based on the conventional wis
of the ground water hydrologists of the 1940's and
that continued overdraft of ground water basins
undesirable. However these limitations on minin
ground water often have limited the potential us
ness of basins to offset variations in annual preci
tion and particularly to postpone or reduce the r
for importations of water. Recent studies of gro
water basins have indicated that the dangers of pe
nent damage from overproduction have been over
to the courts.

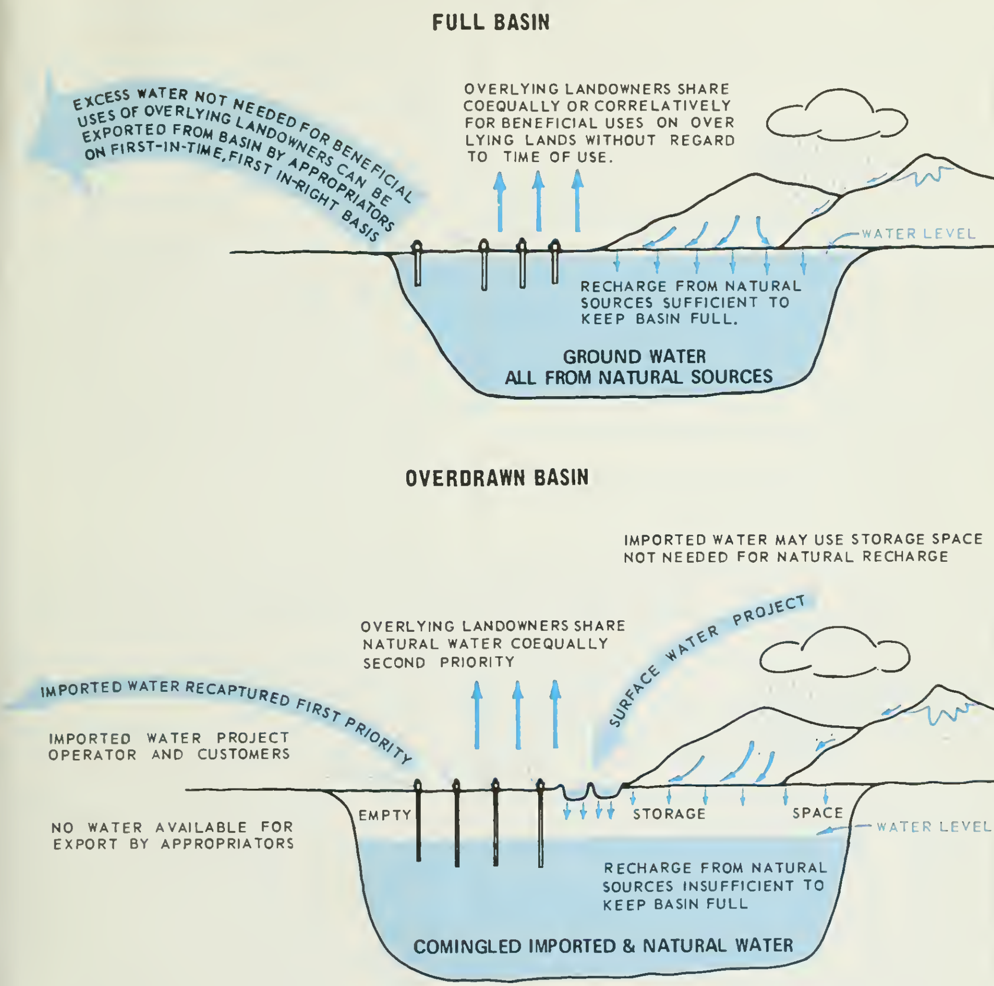
[1] An exception is water in subterranean streams which is subject to a statutory
system under the jurisdiction of the State Water Resources Control Board (Wat
Section 1200). However all hydrologists agree that almost none of California's
water resources flows in subterranean streams

[2] *Katz* v *Walkinshaw*, 141 Cal 116, 70 Pac. 663, 74 Pac. 766 (1902-3)

[3] *City of Pasadena* v *City of Alhambra*, 33 Cal 2d 908, 207 P 2d 17 (1949)

[4] *City of Los Angeles* v *City of San Fernando, et al.*, _____ Cal 3d _____ (1975)

RIGHTS TO GROUND WATER



Notes:

- Total uses of water limited to amount which will not do permanent damage to basin or have adverse effects on the basins long-term supply.
- Old Pasadena vs Alhambra 'mutual prescription" rule which apportioned water among all users both overlying and appropriative on basis of uses during the last 5 years of overdraft prior to filing adjudicatory action is no longer the law. The case of Los Angeles vs San Fernando overturned the "Mutual prescription" doctrine and held prescriptive rights do not apply against Public entities.
- Also the old Pasadena vs Alhambra rule which limited ground water withdrawals of overlying landowners and appropriators to the "safe yields," that is, the average annual natural recharge of the basin, has been modified to allow withdrawals in amounts which will not adversly effect the basin.

Figure 26. Rights to Ground Water

Each of the earlier court decrees was meant to solve a particular problem at a particular time. Thus most of these judgments do not lend themselves to a system of conjunctive use of surface and ground water, which is discussed later in this report. In particular the courts did not separately consider the rights to empty storage space in a drawn down basin.

Almost all of California's ground water basins are within the boundaries of several agencies with jurisdiction over water resources, but with widely varying authority as to ground water management. Unless one agency with adequate authority embraces all or nearly all of a basin within its boundaries, agreement on an overall management plan is very difficult. Efficient conjunctive operation of ground water basins requires that an agency or group of agencies acting under the Joint Exercise of Powers Act has authority to manage the basin; that is, authority to store and withdraw water and to control the ground water levels in the basin. Few major water project operators in California presently have such authority and because of the proliferation of small districts there are few, if any, basinwide entities with authority over any of California's major ground water basins.[5]

A careful analysis of the Supreme Court's *San Fernando* decision would indicate that this decision presages the dawn of a new era in the law and will greatly facilitate the conjunctive use of California's ground water basins—at least in those basins which have been overdrawn to a point that there is more empty storage space than is presently being used.

The Court was considering the rights to the San Fernando ground water basins on the northern edge of Los Angeles. In one part of the decision the Court held that a public entity cannot lose its rights by prescription. This holding will effectively rule out any future "mutual prescription" settlements or judgments in basins where some or all of the rights are held by public entities.

As to the rights to the natural yield of the basin, the Court found that Los Angeles has prior rights to all of the yield pursuant to its pueblo right acquired under Spanish law. This pueblo right was held to be superior to the rights of all overlying landowners.

However, for the future of conjunctive use of ground water basins, the Court's holding with respect to the rights to the empty storage space in the basin is the most important. The court upheld the rights of all of the owners of water imported from outside of the basin to recover from the ground water basin all of such imported water which reached the ground water whether by deliberate spreading or by incidental percolation after surface use. The Court held that the rights to recover such imported water are of equal priority to the City of Los Angeles' pueblo right and are "*prior to the rights dependent on ownership of overlying land or based solely upon appropriation of ground water from the basin*".

The Court noted that there did not appear to be any shortage of underground storage space in relation to the demand, and therefore it was unnecessary to determine priorities to the use of such space.

Under these rulings, it appears that in any ground water basin in which storage space exceeds the present uses, including the maximum space needed for wet-year natural recharge, then the operator of a major water project or its water customer would be protected if the operator elects to commence a spreading program. The project operator (or its customer) would have a prior right to recapture such water and could protect this right against overlying landowners and other users.

The most efficient use of a ground water basin would still call for overall management of all uses. Nonetheless, this right to store and recapture imported water could be a considerable adjunct to project operation and could serve to add to the project yield and delivery capability.

Besides earlier laws to prevent waste of water, particularly from artesian wells, and to require reporting of ground water pumping in certain water-short Southern California counties, the Legislature now has adopted comprehensive laws for the protection of ground water basins from pollution.

The next important consideration is the need to establish a framework for more complete control and management of ground water basins in conjunction with surface water supplies for the benefit not only of the local landowners but all the people of California. As we have noted, considerable authority already exists. However, it may still be prudent to seek specific legislative authority before proceeding with any major program for use of ground water basins in conjunction with imported surface supplies from the State Water Project or any other major surface water project. Legislation would be particularly needed if there are competing uses for all of the available storage space in a basin.

[5] For a broader discussion of the legal problems of conjunctive use see Department of Water Resources Southern District Report dated June 1974 entitled "Ground Water Storage of State Water Project Supplies".

CHAPTER V. OPPORTUNITIES FOR BASIN MANAGEMENT AND FUTURE STUDIES

With certain exceptions, basin management has been limited principally to meeting the needs of overlying landowners. Important concepts that have long influenced basin management plans include safe yield, salt balance, and maintenance of water quality for beneficial use. A more recent concept is nondegradation of water quality. Today, however, even broader concepts are under consideration.

New Concepts in Basin Management

Operation of ground water basins to more fully use their vast storage capacity in conjunction with surface water has great potential in California. The surface water facilities now enable water originating in the north coastal area to reach the Mexican Border and water from the Colorado river to cross the State to the south coast. Considerable additional studies, some general and some very specific, will be needed to develop the potential available in these huge water systems. The Department of Water Resources is assisting in these studies to encourage local basin managers to utilize their basins more fully for statewide benefits. Several concepts based on the development of this unused storage capacity are discussed in the following paragraphs.

Storage of State Water Project Water

The Southern California Water Conference and the Department of Water Resources have made preliminary studies of storage of State Water Project water in Southern California ground water basins, where several million acre-feet of storage capacity is empty of water. Storage of water—which could be conveyed through unused capacity of the Project aqueduct—could provide supplies for use during dry periods or during any prolonged disruption of Project service. These supplies would also supplement surface storage in Southern California. The level of water in the basins would be higher, thus decreasing the pumping lift and energy requirements for local agencies using the basins.

California Aqueduct—San Joaquin Valley

The studies indicate that about 2.6 million acre-feet of water will be available to be placed underground during the next five years. This would defer the time at which additional conservation facilities would be needed in Northern California to meet the increasing water requirements of the State Water Project.

Some areas in the San Joaquin Valley are also being examined to determine if State Water Project water can be stored underground in space presently empty in that ground water basin.

Cyclic Storage of Water

A further possibility that warrants study is a carefully coordinated operation of the State Water Project and storage space in some of Southern California's and San Joaquin Valley's ground water basins to determine the feasibility of long-term recharge and use of storage to permanently increase the dry period yield of the State Water project. This study would also include a determination of need for additional aqueduct capacity and the feasibility of providing the increased capacity.

Conjunctive Operation of Surface Supplies with Ground Water Basins

Some of the large ground water basins in the State, particularly those in the Sacramento and San Joaquin Valleys, have potential for use of part of their storage capacity in conjunction with surface supplies to meet increased water demands at any location in California to which water may economically be transported from the Central Valley.

The concept has two basic variations. The first variation, filling empty storage space in advance of use (Table I), now under consideration for the State Water Project, has had considerable attention. The second possibility is to use and then replace water from a basin that is presently full. Basins which are now largely served by surface supplies are the most promising because of the recharge of the basins from irrigation and conveyance losses. Suitable well and collection facilities would have to be installed to enable water to be taken from the storage in the basin during a dry year, or a period of dry years, and transported to places of use through conveyance facilities such as those of the California State Water Project or the Central Valley Project.

An alternative method would be to use water from the ground water basin on the overlying lands during dry periods and to divert the usual surface supplies of the area to other areas that lack a reserve supply of ground water. Such a plan might require new economic procedures to assure equitable allocation of costs.

Ground Water Pumped into Irrigation Canal

Table 1. Empty Ground Water Storage Capacity

Basin No.	Basin Name	Empty Capacity Acre-feet
2-9	Santa Clara Valley (San Jose Area)	300,000
3-3	Gilroy-Hollister Valley	300,000
4-2	Ojai Valley	45,000
4-4	Santa Clara River Valley	150,000
4-4.07	Santa Clara River Valley—Eastern Basin	20,000
4-8	Las Posas Valley	650,000
4-12	San Fernando Valley	500,000
4-13	San Gabriel Valley	
	Raymond Basin	150,000
	San Gabriel Basin	100,000
5-21	Sacramento Valley (Sacramento County)	1,500,000
5-22	San Joaquin valley	
	San Joaquin Basin	10,500,000
	Tulare Basin	35,000,000
8-1	Coastal Plain—Orange County	250,000
8-2	Upper Santa Ana	
	Chino Basin	1,800,000
	Bunker Hill—San Timoteo Basin	500,000
8-5	San Jacinto Basin	320,000
9-5	Temecula Valley	50,000
		52,135,000

A detailed study might reveal some combination of ground water use on overlying lands and export of ground water that would be most satisfactory.

Advantages and Problems in Conjunctive Use of Surface and Ground Water

A major advantage of use of large volumes of underground storage capacity for regulation of surface supplies is the decreased need for construction of costly surface storage reservoirs. Evaporation from the ground water basins will be much lower than that from equivalent surface storage. Moreover, water stored in the ground water basins is less prone to natural or man-caused deterioration than is water in surface reservoirs.

There are also some problems associated with conjunctive operation. Lowering of the water levels in the ground water basins which contain clay layers if extensive and over several years may be accompanied by significant land subsidence. Because of receding ground water levels, existing wells in basins operated conjunctively may require lowering of pump bowls, deepening or replacement. In addition, energy will be required to remove the water from the basin.

Pump Taxes

In the implementation of selected ground water basin management plans, one of the most powerful tools available to water districts is the authority to make financial assessments for use of ground water underlying the district. Existing authorities are the following two types:

1. Broad and complex assessment formulas for purchase of imported water for recharge and use of pump taxes on the ground water withdrawn; and
2. Flexible authority for assessing relative benefits within a water district depending upon the benefits or detriments which accrue to landowners overlying or adjacent to the basin or whose ground waters are influenced by districtwide imported water supplies or planned recharge and use of ground water.

Legislation is presently under consideration that would provide specific short-term authority, along with a schedule for termination of authority, for trial purchase and recharge of ground water.

A survey of these authorities and their use would be helpful to any district preparing to develop a ground water management plan.

To the Department of Water Resources' current knowledge, only five of the twelve agencies specifically authorized to do so are actively imposing user pump taxes to manage their ground water resources. Additionally, about seven agencies are considering plans for some form of pump tax in the future.

Mining Ground Water

Many ground water basins have enabled development of a significant economic base, either urban or agricultural, by withdrawing substantial quantities of water from storage in an underlying basin (mining) as discussed earlier in this report. In most cases, addition-

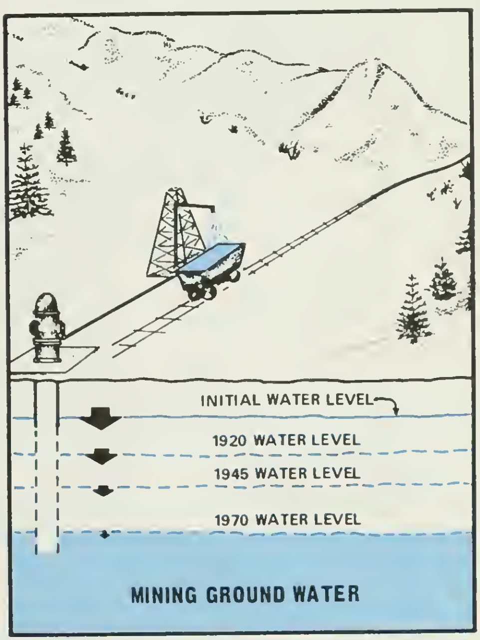


Figure 27. Mining Ground Water

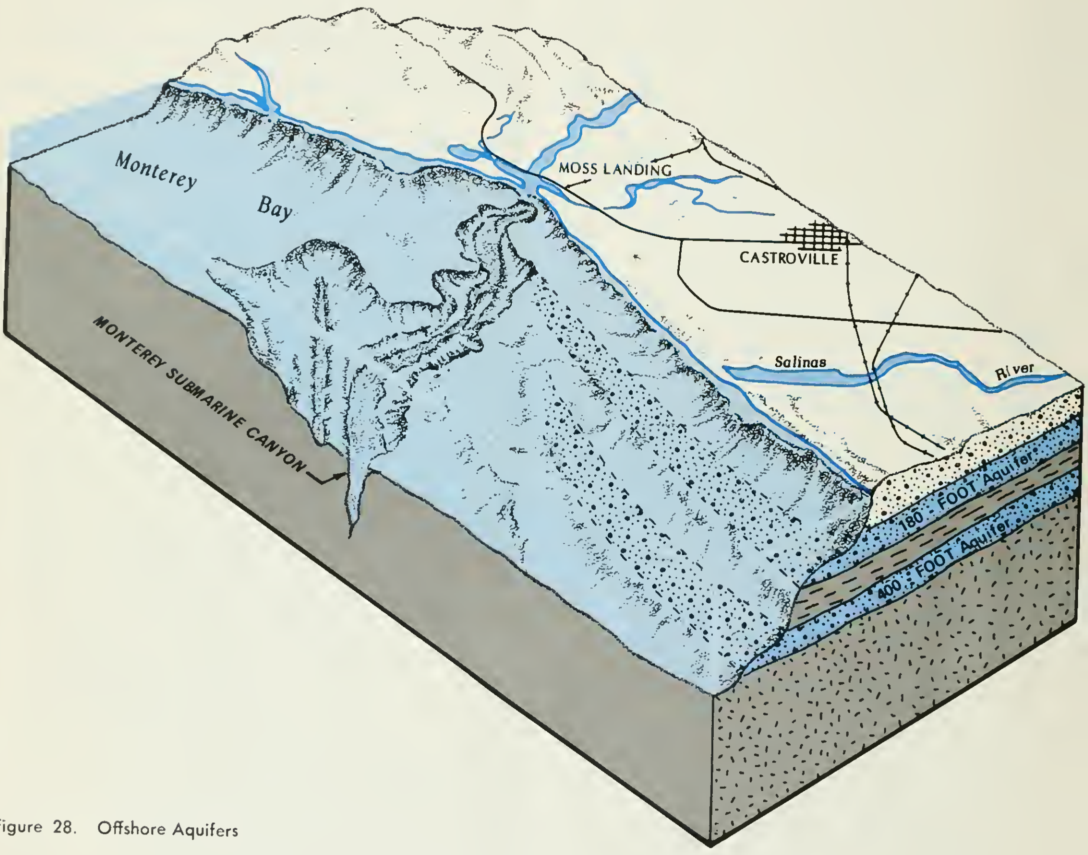


Figure 28. Offshore Aquifers

al recharge of the basin has subsequently been accomplished by either regulation of local surface supplies or importation of water.

This management tool still has potential use. Mining basins to expand a local economy is occurring in some parts of the San Joaquin Valley and may continue for a number of years before the ground water overdraft is replaced by an imported surface supply. Mining ground water is also a possibility for thermal-electric power plant cooling in some of the desert basins in Southern California. The underlying ground water would meet the cooling-water needs over the economic life of the power plant without provision for replacement of the water after that time. Basins that contain brackish water would be particularly well-suited to this use and are the only ones that should be considered initially.

Unused Bodies of Ground Water

A ground water basin underlies South San Francisco Bay, and aquifers are known to extend considerable distances offshore in both Ventura and San Luis Obispo Counties. In each of these cases, a fresh water aquifer underlies a surface body of salt water, but is hydraulically separated from the salt water by impermeable clay strata. Limited use has been made in the past of the fresh water under South San Francisco Bay, and some thought has been given to withdrawal of fresh water from the offshore basins in Ventura and San Luis Obispo Counties.

Some salt water has reached the fresh water body at San Francisco Bay, possibly through natural or man-made breaks in the overlying clays, or possibly through seepage of salt water through the clays because of lowering of the water pressure in the underlying aquifer due to pumping from the landward portion of the ground water basin. Further use of water from these basins would require careful advance study to ensure against unintentional damage to the water quality in the basins.

The desert area in the southeastern portion of California consists mainly of mountainous areas and alluvium-filled valleys in about equal proportions. Most of the alluvium is filled with ground water and is sufficiently permeable to yield water to wells. Part of the basins contain fresh water suitable for most uses. Many contain brackish water that is unsuited for urban or agricultural uses.

Recharge of the basins is very limited in relation to their area and storage capacity. Use of water from the basins over a long period of time requires importation of water from some distant source. The basins can be mined for various purposes, including use of brackish water for thermal power plant cooling. Further development of the water in these basins would require a good deal of additional study but should not be overlooked.

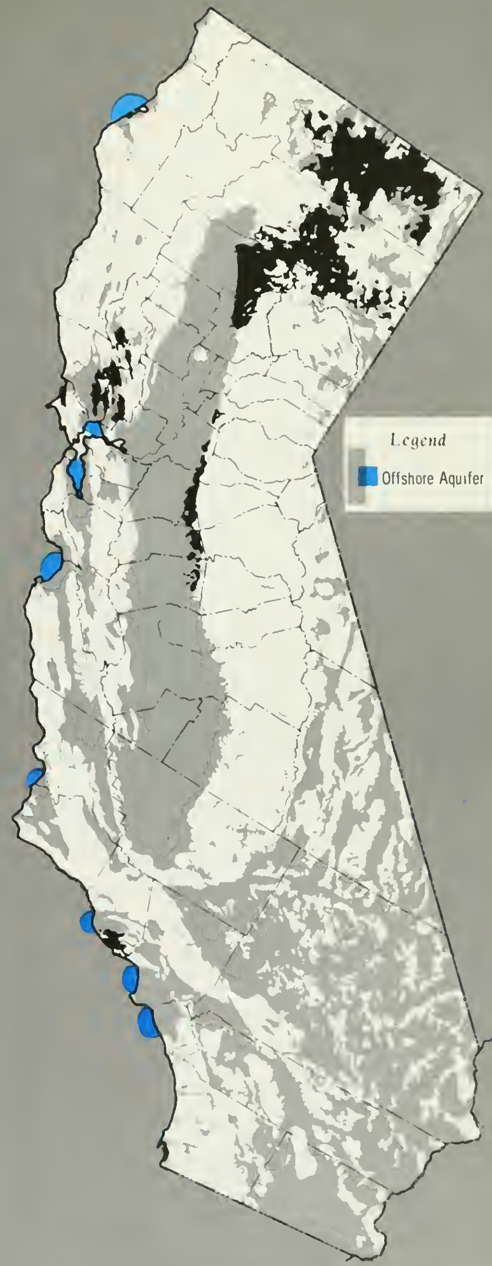


Figure 29. Fresh Water in Offshore Aquifers

Ground Water in Bedrock Areas

Outside the recognized ground water basins, experience has shown that small quantities of ground water can be obtained from wells in geologic formations that are usually regarded as nonwater-bearing. The water frequently occurs in fractures in bedrock material or in sedimentary rocks with limited water storage space. Although there is considerable risk of any given well being dry when drilled or becoming dry during a drought year, wells in such areas supply many single-family homes.

Some limited studies by the Department of Water Resources of this occurrence of ground water show that favorable areas for occurrence of ground water in rock areas can be identified. Use of the information assembled in such a study can greatly increase the possibility of locating homes and wells where a little water can be obtained from such formations. Such studies are a worthwhile element of any comprehensive reconnaissance level study of the water resources of individual areas of the State.

Ground Water Basin Studies

Most of the highly developed ground water basins in the State have been studied several times at increasing levels of intensity. Such a sequence of study is usually necessary, because each study builds upon the knowledge and data from the earlier study and upon the knowledge gained through construction and use of wells as the basin has developed. Except for surface geology, very little information can be easily obtained for study of undeveloped basins. Much additional information can be obtained by construction of test wells and by seismic surveys, but both are very expensive.

The usual sequence of development of knowledge is somewhat as follows:

(a) Surface water hydrology and water use
(b) Basin configuration and surface geology
(c) Ground water storage capacity
(d) Ground water occurrence, movement, and replenishment
(e) Quality of the water
(f) Mathematical models of the basin's hydrology and water quality.

Mathematical models can be employed at several stages of study of a basin. However, models contribute a substantially new body of knowledge only when applied to highly developed basins that have had a good deal of earlier study and for which a large body of data is available. The first attempt at mathematical modelling of a basin usually reveals that additional data are needed and sometimes indicates existence of certain types of geologic formations that require further definition before a mathematical model of the basin can be verified.

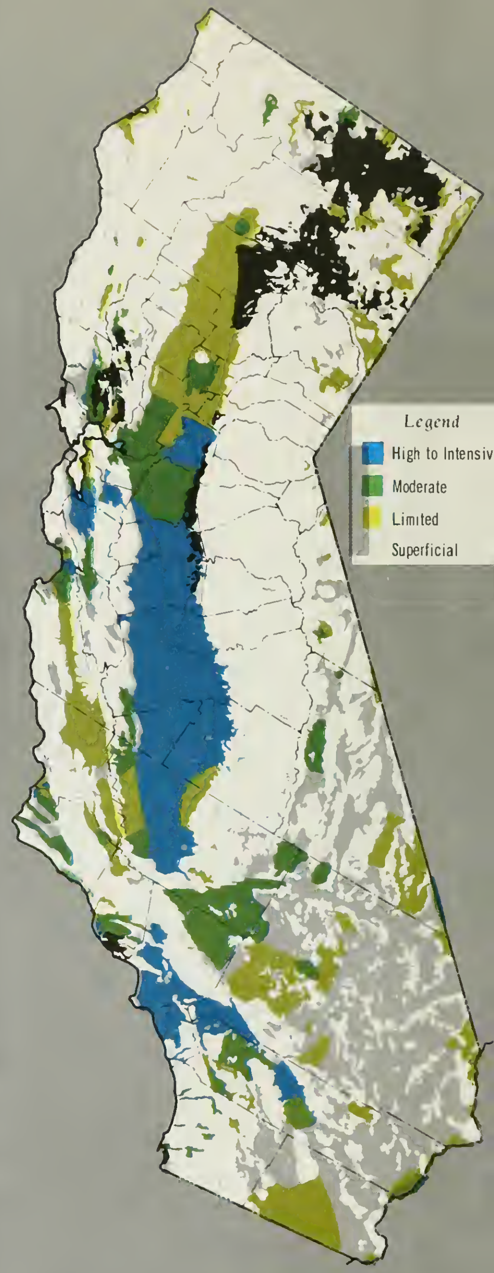


Figure 30. Degree of Geologic Knowledge

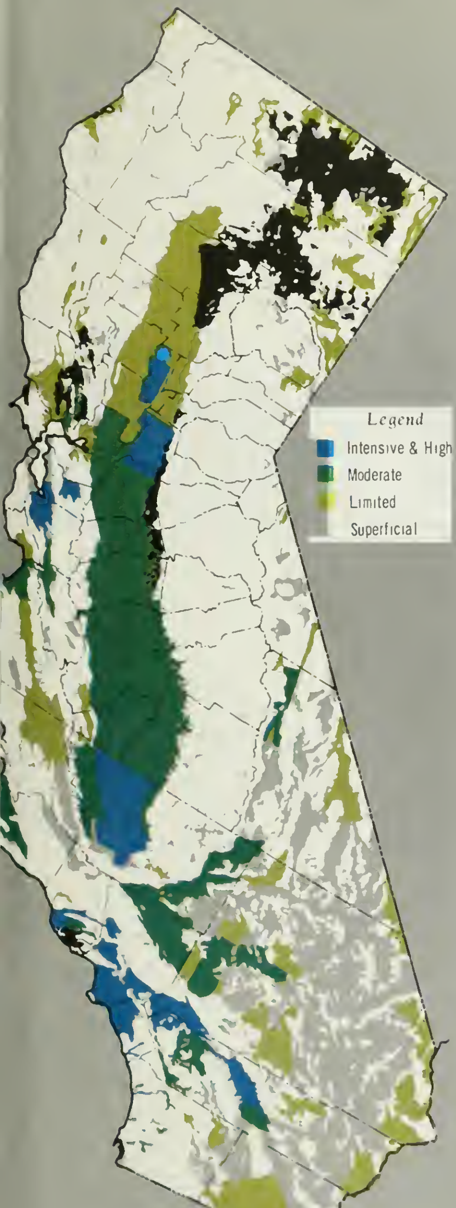


Figure 31. Degree of Hydrologic Knowledge

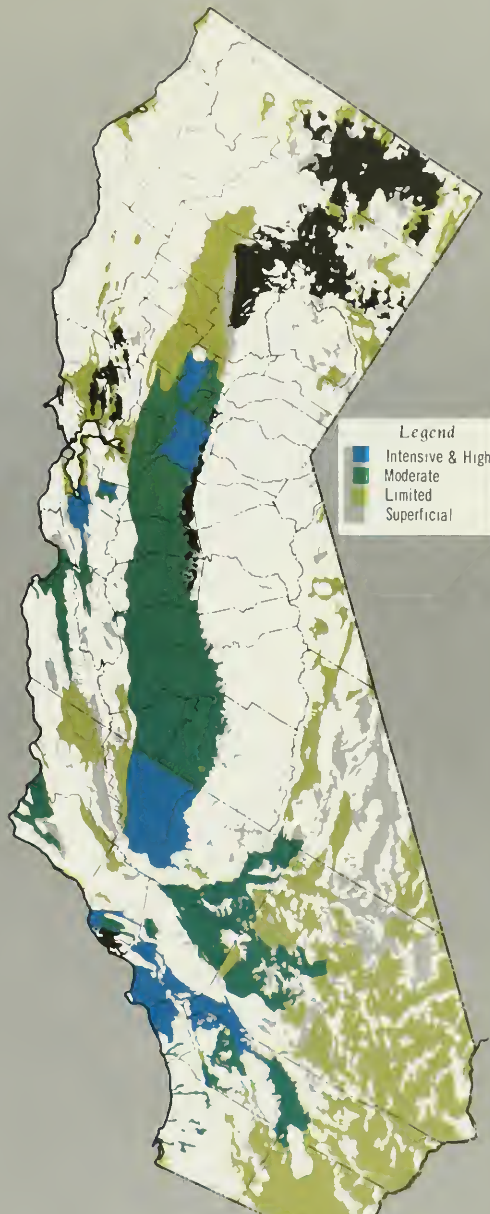


Figure 32. Degree of Water Quality Knowledge

The models permit evaluation of the probable effect of different patterns and locations of recharge of the basin, and different patterns and locations of extraction of water from the basins. The physical changes indicated by the model can be evaluated in terms of cost so that the economic consequences of various methods of operation of the basin can be estimated.

Some preliminary adaptations of models have been developed to measure changes in quality that can be expected with introduction of water of different quality than that presently in the basin. The models enable managers of a basin to obtain quantitative estimates of the effects and costs of a variety of different operation plans before making any substantial commitment to the cost of physical works to carry out a particular management plan. Modelling is a tool of great interest to ground water basin managers, and its use may soon progress to the point where some basins in California are being managed in accordance with plans based on mathematical models.

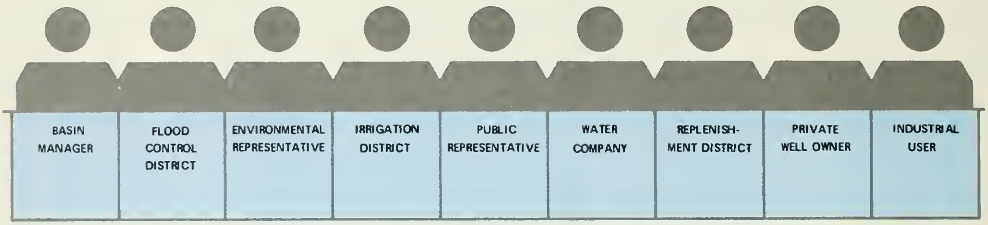


Figure 33. Conference on Ground Water Basin Management

Table 2. Metric Conversion Factors
English to Metric System of Measurement

Quantity	English unit	Multiply by	To get metric equivalent
Length	inches	2.54	centimeters
	feet	30.48	centimeters
		0.3048	meters
		0.0003048	kilometers
	yards	0.9144	meters
	miles	1,609.3	meters
		1.6093	kilometers
Area	square yards	0.83613	square meters
	acres	0.40469	hectares
		4,046.9	square meters
		0.0040469	square kilometers
	square miles	2.5898	square kilometers
Volume	gallons	0.0037854	cubic meters
		3.7854	liters
	acre-feet	1,233.5	cubic meters
		1,233,500.0	liters
	cubic feet	0.028317	cubic meters
	cubic yards	0.76455	cubic meters
		764.55	liters
Velocity	feet per second	0.3048	meters per second
	miles per hour	1.6093	kilometers per hour
Discharge	cubic feet per second	0.028317	cubic meters per second
	gallons per minute	3.7854	liters per minute
		.0037854	cubic meters per second
Weight (Mass)	pounds	0.45359	kilograms
	tons (2,000 pounds)	0.90718	tons (metric)
Temperature	degrees Fahrenheit	$\frac{t_F - 32}{1.8}$	degrees Celsius
Concentration	parts per million	1.0 (Approx.)	milligrams per liter
Electrical conductance	mho	1.0	siemens

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